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REALITY CHECK: THE IMPACT AND ACHIEVABILITY OF EPA'S PROPOSED OZONE STANDARDS

HEARING

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTEENTH CONGRESS

FIRST SESSION

MARCH 17, 2015

Serial No. 114–10

Printed for the use of the Committee on Science, Space, and Technology

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CONTENTS

March 17, 2015

Page

Witness List 2

Hearing Charter 3

Opening Statements

Statement by Representative Lamar S. Smith, Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives 9
  Written Statement 10

Statement by Representative Eddie Bernice Johnson, Ranking Minority Member, Committee on Science, Space, and Technology, U.S. House of Representatives 11
  Written Statement 13

Witnesses:

Mr. Harry C. Alford, President and CEO, National Black Chamber of Commerce
  Oral Statement 15
  Written Statement 17

Mr. Raymond Keating, Chief Economist, Small Business & Entrepreneurship Council
  Oral Statement 23
  Written Statement 25

Dr. Mary B. Rice, Instructor in Medicine, Harvard Medical School, Pulmonary and Critical Care Physician, Division of Pulmonary, Critical Care and Sleep Medicine, Beth Israel Deaconess Medical Center, Boston MA
  Oral Statement 35
  Written Statement 37

Dr. Allen S. Lefohn, President, A.S.L. & Associates
  Oral Statement 44
  Written Statement 46

Mr. Eldon Heaston, Executive Director, Mojave Desert AQMD, Antelope Valley AQMD
  Oral Statement 54
  Written Statement 56

Discussion 61

Appendix I: Answers to Post-Hearing Questions

Mr. Harry C. Alford, President and CEO, National Black Chamber of Commerce 90

Mr. Raymond Keating, Chief Economist, Small Business & Entrepreneurship Council 91

Dr. Mary B. Rice, Instructor in Medicine, Harvard Medical School, Pulmonary and Critical Care Physician, Division of Pulmonary, Critical Care and Sleep Medicine, Beth Israel Deaconess Medical Center, Boston MA 97

Dr. Allen S. Lefohn, President, A.S.L. & Associates 101

Page
Mr. Eldon Heaston, Executive Director, Mojave Desert AQMD, Antelope Valley AQMD 199

Appendix II: Additional Material for the Record

Documents submitted by Representative Eddie Bernice Johnson, Ranking Member, Committee on Science, Space, and Technology, U.S. House of Representatives 204
Letter submitted by Representative Suzanne Bonamici, Committee on Science, Space, and Technology, U.S. House of Representatives 250
Documents submitted by Representative Jim Bridenstine, Committee on Science, Space, and Technology, U.S. House of Representatives 265
Article submitted by Representative Randy K. Weber, Committee on Science, Space, and Technology, U.S. House of Representatives 292
Letter submitted by Representative John R. Moolenaar, Committee on Science, Space, and Technology, U.S. House of Representatives 300
Letter submitted by Representative Thomas Massie, Committee on Science, Space, and Technology, U.S. House of Representatives 308
Letter submitted by Representative Gary Palmer, Committee on Science, Space, and Technology, U.S. House of Representatives 310
Documents submitted by Representative Bruce Westerman, Committee on Science, Space, and Technology, U.S. House of Representatives 312
Letter submitted by Representative Frank D. Lucas, Committee on Science, Space, and Technology, U.S. House of Representatives 320
Documents submitted by Representative Lamar Smith, Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives 323

REALITY CHECK: THE IMPACT AND ACHIEVABILITY OF EPA'S PROPOSED OZONE STANDARDS

TUESDAY, MARCH 17, 2015

House of Representatives,
Committee on Science, Space, and Technology,
Washington, D.C.

The Committee met, pursuant to call, at 10:03 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Lamar Smith [Chairman of the Committee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congreſs of the United States
House of Representatives
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-6301
(202) 225-6371
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Full Committee

Reality Check: The Impact and Achievability of EPA's Proposed Ozone Standards

Tuesday, March 17, 2015
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

Mr. Harry C. Alford, President and CEO, National Black Chamber of Commerce

Mr. Raymond Keating, Chief Economist, Small Business & Entrepreneurship Council

Dr. Mary B. Rice, Instructor in Medicine, Harvard Medical School; Pulmonary and Critical Care Physician, Division of Pulmonary, Critical Care and Sleep Medicine, Beth Israel Deaconess Medical Center

Dr. Allen S. Lefohn, President, A.S.L. & Associates

Mr. Eldon Heaston, Executive Director, Mojave Desert AQMD, Antelope Valley AQMD

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HEARING CHARTER

Reality Check: The Impact and Achievability of EPA's Proposed Ozone Standards

Tuesday, March 17, 2015
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

PURPOSE

The House Science, Space and Technology Committee will hold a hearing entitled *Reality Check: The Impact and Achievability of EPA's Proposed Ozone Standards* on Tuesday, March 17, 2015, at 10:00 a.m. in Room 2318 of the Rayburn House Office Building. The purpose of the hearing is to examine the scientific basis and technological achievability of the Environmental Protection Agency's (EPA) proposed National Ambient Air Quality Standards (NAAQS) for ozone. In addition, witnesses will discuss impacts of these proposed national standards from a state and local perspective.

WITNESS LIST

- **Mr. Harry C. Alford,** President and CEO, National Black Chamber of Commerce
- **Mr. Ray Keating**, Chief Economist, Small Business & Entrepreneurship Council
- **Dr. Mary B. Rice**, Instructor in Medicine, Harvard Medical School; Pulmonary and Critical Care Physician, Division of Pulmonary, Critical Care and Sleep Medicine, Beth Israel Deaconess Medical Center
- **Dr. Allen S. Lefohn**, President, A.S.L. & Associates
- **Mr. Eldon Heaston**, Executive Director, Mojave Desert and Antelope Valley Air Quality Management District

BACKGROUND

Ozone (O_3) is a gas that occurs both in the Earth's upper atmosphere as well as at ground level (troposphere). Ozone in the upper atmosphere helps protect the earth from the sun's harmful rays such as ultraviolet radiation. Ozone at ground level is not directly emitted into the air, but instead is created by chemical reactions between precursor emissions, specifically nitrogen oxide (NOx) and volatile organic compounds (VOC).[1] Ground level ozone is commonly referred to as smog.

The Clean Air Act of 1970 (P.L. 91-604, with major legislative updates in 1977 and 1990) directed EPA to set NAAQS for pollutants considered harmful to public health and the environment.[2] EPA has set standards for six criteria pollutants, including carbon monoxide, lead, nitrogen dioxide, ozone, particle pollution (particulate matter), and sulfur dioxide. The Clean Air Act specifies two categories of standards: primary standards for public health protection and secondary standards for public welfare protection.

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[1] http://www.epa.gov/air/ozonepollution/basic.html

The Clean Air Act requires EPA to review the NAAQS every five years to ensure adequate health and environmental protection is being provided. In 1997, EPA replaced the existing ozone NAAQS with an 8-hour standard of 84 parts per billion (using standard rounding conventions). In 2008, EPA issued a final rule revising the ozone standard to a level of 75 parts per billion.[3] Just recently, however, on February 13, 2015, EPA finalized[4] the requirements establishing that state, tribal, and local air quality management agencies must meet for areas where air quality exceeds the 2008 NAAQS.[5] In July 2011, outside of the normal five year review process, EPA submitted a draft final rule for reconsideration of the 2008 ozone NAAQS that President Obama then subsequently withdrew in September 2011.[6]

Based on the advice of the Clean Air Scientific Advisory Committee (CASAC), the EPA proposed an updated ozone NAAQS which appeared in the Federal Register on December 17, 2014.[7] The proposal would set more stringent standards, by lowering the primary standard from the current 75 parts per billion (ppb) to a range of 65 to 70 ppb. Publication in the Federal Register begins the public comment period that ends on March 17, 2015. The agency must address significant public comments when it publishes the final standard.

COMPLIANCE WITH THE NAAQS

When the EPA revises the NAAQS for ozone, it must designate areas in the US which meet *attainment* or *nonattainment* of the standard. Attainment refers to a state or region complying with federal regulations, while nonattainment means that an area is exceeding the regulated limit. States must individually develop a plan to comply with the NAAQS, including proposals for brining nonattainment areas into attainment. Reductions in ozone levels can be achieved by a variety of methods including pollution control technologies. Ozone control technologies generally target nitrogen oxides (NOx) and volatile organic compounds (VOCs). Control strategies focus on mission limits along with control equipment that may address specific industrial processes. State environmental agencies must then develop State Implementation Plans (SIPs).[8] Specifically, after each revised NAAQS is promulgated, both the EPA and states must undertake the following actions:

- **"Within two years after NAAQS promulgation:** With input from the states and tribes, EPA must identify or "designate" areas as meeting (attainment areas) or not meeting

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[2] http://www.epa.gov/air/criteria.html

[3] http://www.gpo.gov/fdsys/pkg/FR-2008-03-27/html/E8-5645.htm

[4] http://www.epa.gov/groundlevelozone/actions.html#feb2015i

[5] http://www.epa.gov/groundlevelozone/pdfs/20150213fr.pdf

[6] http://www.whitehouse.gov/the-press-office/2011/09/02/statement-president-ozone-national-ambient-air-quality-standards

[7] http://www.gpo.gov/fdsys/pkg/FR-2014-12-17/pdf/2014-28674.pdf

[8] http://www.epa.gov/airquality/urbanair/sipstatus/overview.html

(nonattainment areas) the standards. Designations are based on the most recent set of air monitoring data.

- **Within three years after NAAQS promulgation:** All states must submit plans, known as state implementation plans (SIPs), to show they have the basic air quality management program components in place to implement a new or revised NAAQS, as specified in Clean Air Act section 110.
- **Within 18-36 months after designations:** Due dates for nonattainment area SIPs are based on the area designation date and vary by pollutant and area classification. SIPs for Ozone, $PM_{2.5}$, and CO nonattainment areas are generally due within 36 months from the date of designation. Each nonattainment area SIP must outline the strategies and emissions control measures that show how the area will improve air quality and meet the NAAQS. In addition, the CAA mandates that areas adopt certain specified control requirements."[9]

After a state submits its SIP, EPA then reviews and either approves it in full, in part, or disapproves. The public has an opportunity to submit comments on EPA's proposed actions. If a state fails to submit a plan or if EPA disapproves of the plan, EPA is required to develop a federal implementation plan.[10]

ADDITIONAL READING

- U.S. Environmental Protection Agency, National Ambient Air Quality Standards for Ozone, Proposed Rule. Available at: https://www.federalregister.gov/articles/2014/12/17/2014-28674/national-ambient-air-quality-standards-for-ozone
- U.S. Environmental Protection Agency, Regulatory Impact Analysis of the Proposed Revisions to the National Ambient Air Quality Standards for Ground-Level Ozone. Available at: http://www.epa.gov/ttn/ecas/regdata/RIAs/20141125ria.pdf

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[9] http://www.epa.gov/airquality/urbanair/sipstatus/process.html

[10] Ibid

Appendix A:

Table of Historical Ozone NAAQS[11]

Final Rule/Decision	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1971 36 FR 8186 Apr 30, 1971	Primary and Secondary	Total photochemical oxidants	1-hour	0.08 ppm	Not to be exceeded more than one hour per year
1979 44 FR 8202 Feb 8, 1979	Primary and Secondary	O_3	1-hour	0.12 ppm	Attainment is defined when the expected number of days per calendar year, with maximum hourly average concentration greater than 0.12 ppm, is equal to or less than 1
1993 58 FR 13008 Mar 9, 1993	EPA decided that revisions to the standards were not warranted at the time				
1997 62 FR 38856 Jul 18, 1997	Primary and Secondary	O_3	8-hour	0.08 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
2008 73 FR 16483 Mar 27, 2008	Primary and Secondary	O_3	8-hour	0.075 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years

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[11] http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_history.html

Appendix B:

Percent Change in Air Quality[12]

	1980 vs. 2013	1990 vs. 2013	2000 vs. 2013
Carbon Monoxide (CO)	-84	-76	-59
Ozone (O_3) (8-hr)	-33	-23	-18
Lead (Pb)	-92	-87	-60
Nitrogen Dioxide (NO_2) (annual)	-58	-50	-40
Nitrogen Dioxide (NO_2) (1-hour)	-60	-46	-29
PM_{10} (24-hr)	---	-34	-30
$PM_{2.5}$ (annual)	---	---	-34
$PM_{2.5}$ (24-hr)	---	---	-34
Sulfur Dioxide (SO_2) (1-hour)	-81	-76	-62

Notes:

1. --- Trend data not available
2. Negative numbers indicate improvements in air quality
3. In 2010, EPA established new 1-hour average National Ambient Air Quality Standards for NO2 and SO2

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[12] http://www.epa.gov/airtrends/aqtrends.html

Appendix C:

Percent Change in Emissions:[13]

	1980 vs. 2013	1990 vs. 2013	2000 vs. 2013
Carbon Monoxide (CO)	-67	-59	-42
Lead (Pb)	-99	-80	-50
Nitrogen Oxides (NO_x)	-52	-48	-41
Volatile Organic Compounds (VOC)	-53	-39	-18
Direct PM_{10}	-50	-20	-17
Direct $PM_{2.5}$	---	-24	-32
Sulfur Dioxide (SO_2)	-81	-78	-69

Notes:
1. --- Trend data not available
2. Direct PM10 emissions for 1980 are based on data since 1985
3. Negative numbers indicate reductions in emissions
4. Percent change in emissions based on thousand tons units

National and local air quality trends graphs showing the nation's progress towards clean air are available for: carbon monoxide (CO), ozone (O_3), lead (Pb), nitrogen dioxide (NO_2), particulate matter (PM), and sulfur dioxide (SO_2).

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[13] http://www.epa.gov/airtrends/aqtrends.html

Chairman SMITH. The Committee on Science, Space, and Technology will come to order. Without objection, the Chair is authorized to declare recesses of the Committee at any time. Welcome to today's hearing, titled "Reality Check: The Impact and Achievability of EPA's Proposed Ozone Standards". I will recognize myself for an opening statement, and then the Ranking Member.

Today is the final date to submit comments on the Environmental Protection Agency's proposed National Ambient Air Quality Standards, or as it is sometimes called, NAAQS. The agency's proposal seeks to lower the standard to 65 to 70 parts per billion, from the current 75 parts per billion standard that was set in 2008, and is only now being implemented. Our hearing will review the impact of this proposed regulation, and whether it can be implemented.

By law, the EPA is required to review the ozone standard every five years, but the agency is not required to set new standards. According to EPA's own website, and this is on the PowerPoint screens on either side, according to EPA's own website, since 1980 ozone levels have decreased by 33 percent, while volatile organic compounds have decreased by over 50 percent. The air we breathe is significantly cleaner, and will continue to improve, thanks to new technologies.

However, it is premature and unnecessary for the EPA to propose a new standard when we have not yet given states the opportunity to meet the 2008 standard. Many of the technologies that the EPA forces states to use either do not exist, or will be excessively expensive. In its regulatory impact analysis, the EPA assumes that these controls will somehow just automatically be implemented. As this next chart shows, at 70 parts per billion, over 60 percent of the costs of the program are based upon so-called unknown controls, and at 65 parts per billion, unknown controls become 75 percent of the estimated cost. By the EPA's own admission, this rule is unworkable.

I am also concerned that the science used to justify this rule is not good science. These proposed standards are impossible to meet in some places. The ozone level that occurs naturally would be above the standard set by the EPA, which would mean trying to beat Mother Nature. International transport of ozone from countries like China and Mexico further complicate attaining the existing ozone standards. The EPA has failed to adequately consider these issues. The proposed air quality change could cause many areas to be out of compliance with the Clean Air Act through no fault of their own.

We should all be concerned about the process the EPA used to reach their conclusions. During earlier stages of this rulemaking, EPA relied upon studies with data that was not publicly available. This raises a lot of suspicions. Furthermore, the EPA has regularly chosen to disregard inconvenient scientific conclusions, and muzzled dissenting voices. This hearing provides an example of why we should support both the Secret Science Reform Act, and the Science Advisory Board Reform Act, which are on the House floor this week. The Secret Science Reform Act requires that the EPA use the best available science in an honest and transparent manner. The Science Advisory Board Reform Act promotes fairness, transparency, and public participation to ensure unbiased scientific advice.

There will be serious economic consequences if the EPA moves forward with new ozone standards. Implementation of this rule will cost billions of dollars, and adversely affect many Americans. The cost is certain, but the health benefits are not. Today's witnesses will testify on how this proposed rule will impact American small businesses and job creation. According to the Business Roundtable's analysis, nearly 60 percent of Americans would live in areas of non-attainment, including 45 of 50 states that would be completely or partially violating the standard. A non-attainment designation under the Clean Air Act has serious consequences. It stops new employers from moving into the state. Businesses would be forced to deal with additional burdensome permitting and compliance obligations, which halts expansion and economic development. Ultimately, good jobs will be lost. This rule could be devastating.

Many communities still struggle to meet the standards that were set in 2008. Other communities have never met the standards set in 1979. State and local municipalities will bear the brunt of the regulatory cost. Tighter regulations also will hamper economic recovery, and put additional burdens on the backs of hard working American families. According to a February 2015 National Economic Research Associates comprehensive study, average annual household consumption could be reduced by $830 per year. In addition, families will have to pay for higher energy costs.

In 2010 businesses and communities across the country protested the EPA's efforts to tighten these standards. The overwhelming concerns eventually forced President Obama to withdraw the proposal. The President does not have any reason to propose these new rules, since our air is already becoming clearer. These are the wrong regulations at the wrong time. The EPA should reconsider their proposed rule, and keep the existing 2008 standard.

[The prepared statement of Mr. Smith follows:]

PREPARED STATEMENT OF COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY CHAIRMAN LAMAR SMITH

Today is the final day to submit comments on the Environmental Protection Agency's (EPA's) proposed National Ambient Air Quality Standards (NAAQS).

The Agency's proposal seeks to lower the standard to 65–70 parts per billion (ppb), from the current 75 ppb standard that was set in 2008 and is only now being implemented. Our hearing will review the impact of this proposed regulation and whether it can be implemented.

By law, the EPA is required to review the ozone standard every five years, but the agency is not required to set new standards. According to EPA's own website, since 1980, ozone levels have decreased by 33 percent and Volatile Organic Compounds have decreased by over 50 percent.

The air we breathe is significantly cleaner and will continue to improve thanks to new technologies. However, it is premature and unnecessary for the EPA to propose a new standard when we have not yet given states the opportunity to meet the 2008 standard. Many of the technologies that the EPA forces states to use either do not exist or will be excessively expensive.

In its Regulatory Impact Analysis, the EPA assumes that these controls will somehow just automatically be implemented. As this chart shows, at 70 ppb, over 60 percent of the costs of the program are based on so-called "unknown controls." And at 65 ppb, unknown controls become 75 percent of the estimated costs. By the EPA's own admission, this rule is unworkable.

I am also concerned that the science used to justify this rule is not good science. These proposed standards are impossible to meet in some places. The ozone level that occurs naturally would be above the standard set by the EPA, which would mean trying to beat Mother Nature.

International transport of ozone from countries like China and Mexico further complicate attaining the existing ozone standards. The EPA has failed to adequately consider these issues. We should all be concerned about the process the EPA used to reach their conclusions. During earlier stages of this rule making, EPA relied on studies with data that was not publically available. This raises a lot of suspicions. Furthermore, the EPA has regularly chosen to disregard inconvenient scientific conclusions and muzzled dissenting voices.

This hearing provides an example of why we should support both the Secret Science Reform Act and the Science Advisory Board Reform Act, which are on the House floor this week.

The Secret Science Reform Act requires that the EPA use the best available science in an honest and transparent manner. The Science Advisory Board Reform Act promotes fairness, transparency, and public participation to ensure unbiased scientific advice.

There will be serious economic consequences if the EPA moves forward with new ozone standards. Implementation of this rule will cost billions of dollars and adversely affect many Americans. The cost is certain but the health benefits are not.

Today's witnesses will testify on how this proposed rule will impact American small businesses and job creation. According to the Business Roundtable's analysis, nearly 60 percent of Americans would live in areas of non-attainment, including 45 of 50 states that would be completely or partially violating the standard.

A non-attainment designation under the Clean Air Act has serious consequences. It stops new employers from moving into the state. Businesses would be forced to deal with additional burdensome permitting and compliance obligations, which halt expansion and economic development. Ultimately, good jobs will be lost.

This rule could be devastating. Many communities still struggle to meet the standards that were set in 2008. Other communities have never met the standards set in 1979. State and local municipalities will bear the brunt of the regulatory costs.

Tighter regulations also will hamper economic recovery and put additional burdens on the backs of hard-working American families. According to a February 2015 National Economic Research Associates comprehensive study, the average annual household consumption could be reduced by $830 per year. In addition, families will have to pay for higher energy prices.

In 2010, businesses and communities across the country protested the EPA's efforts to tighten these standards. The overwhelming concerns eventually forced President Obama to withdraw the proposal.

The President does not have any reason to propose these new rules since our air is already becoming cleaner.

These are the wrong regulations at the wrong time. The EPA should reconsider their proposed rule and keep the existing 2008 standard.

Chairman SMITH. Now, that concludes my opening statement, and the gentlewoman from Texas, the Ranking Member, Eddie Bernice Johnson, is recognized for hers.

Ms. JOHNSON. Thank you very much, Mr. Chairman, and thank you to our witnesses for being here this morning. We are here today to discuss the Environmental Protection Agency's proposal to lower the standard for ozone, the pollutant that causes smog, from the current standard of 75 parts per billion to a standard in the range of 65 to 70 parts per billion.

The scientific evidence supports a lower standard for ozone than we currently have. According to the EPA's analysis, strengthening the standard will provide better protection for our children by preventing 320,000 to 960,000 asthma attacks. It will keep them from missing 330,000 to 1 million days in school each year, and it will stop between 750 to 4,300 premature deaths. As someone who worked in the public health field before I entered politics, I am a nurse. I am very sensitive to the problem poor air quality can have on the health of Americans, especially the young and the infirm.

Unfortunately, those of us from Dallas-Fort Worth region—he is from San Antonio, so it must be much better—are very familiar with the negative effects of smog, and are accustomed to seeing orange and red alert warnings about being outside because the air is too polluted to be safe. In fact, the American Lung Association gives the air quality in Dallas a grade of F, which means that the health of our—my constituents is seriously at risk. It is clear that air quality related illnesses have a very real and destructive effect on the economy, on the order of hundreds of billions of dollars annually, and the benefits of reducing those effects will be seen throughout the country.

Despite that, some will argue that EPA's proposed standard will kill jobs, decimate the industrial base, and result in irreparable economic disruption. This is not a new story. It is what has been said for decades about every major environmental and consumer protection, from catalytic converters, to scrubbers, to seat belts. We all know that none of these predictions have come true. In fact, there is much more evidence showing that, on balance, jobs are created, and the economy expands following the passage of major reforms. For example, the U.S. economy grew by 64 percent in the years following the passage of the Clean Air Act. Furthermore, in a report to Congress on the cost and benefits of federal regulations, OMB estimated that major rules promulgated by EPA between 2003 and 2013 had been benefits between $165 billion and $850 billion, compared to the cost of just 38 billion to 46 billion. This is significant return on investment.

And however much we might wish for a world where big environmental issues are addressed voluntarily by industry, or through the workings of the free market, we all know that it just does not work that way. Now more than ever the American people need a strong EPA to protect their right to clean air and clean water. Let me be clear, I am not insensitive to some of the concerns we will likely hear today. But I want to remind everyone that EPA, as required by law, must set the ozone standard at a level that will protect public health based on the science, and not based on cost or technical feasibility. The health of Americans must come first.

That said, I am confident, based on past precedence, that ultimately these regulations act as a catalyst for the creation of new jobs in industrial sectors. Stricter pollution limits force us to push the envelope of scientific innovation and create new technologies. According to the Department of Commerce, the United States is the world's largest producer of environmental protection technologies. Indeed, at $782 billion, the market for environmental goods and services is comparable to the aerospace and pharmaceutical industries, and present important opportunities for the U.S. industry. Thankfully, poll after poll shows that the public agrees with me, and believes—even in Texas, and believes that the EPA should protect their right to clean air and water, more than they believe that pollution is the price they must pay for an economic security.

Although significant process has been made in the past 40 years, it is our job now to build up on the legacy, and ensure that we continue to improve the quality of our air. A strong economy, and a healthy environment, are not mutually exclusive. The Clean Air

Science Advisory Committee recommends lowering the ozone standards, and I think we should listen to our scientists. We can, and must, do better for current and future generations.

I thank you, Mr. Chairman, and yield back.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY RANKING MEMBER EDDIE BERNICE JOHNSON

Thank you, Chairman Smith, and thank you to our witnesses for being here this morning. We are here today to discuss the Environmental Protection Agency's proposal to lower the standard for ozone, the pollutant that causes smog, from the current standard of 75 parts per billion to a standard in the range of 65 to 70 parts per billion. The scientific evidence supports a lower standard for ozone than we currently have. According to the EPA's analysis, strengthening the standard will provide better protection for our children by preventing 320,000 to 960,000 asthma attacks; it will keep them from missing 330,000 to 1 million days in school; and it will stop between 750 and 4,300 premature deaths.

As someone who worked in the public health field before I entered politics, I am very sensitive to the problem poor air quality can have on the health of Americans, especially the young and the infirm. Unfortunately, those of us from the Dallas-Fort Worth region are very familiar with the negative effects of smog and are accustomed to seeing orange and red alerts warning us about being outside because the air is too polluted for it to be safe. In fact, the American LungAssociation gives the air quality in Dallas a grade of F—which means that the health of my constituents is seriously at risk.

It's clear that air quality-related illnesses have a very real and destructive effect on the economy—on the order of hundreds of billions of dollars annually—and the benefits of reducing those effects will be seen throughout the country.

Despite that, some will argue that EPA's proposed standard will kill jobs, decimate the industrial base, and result in irreparable economic disruption. This is not a new story. It's what's been said for decades about every major environmental and consumer protection—from catalytic converters to scrubbers to seatbelts. We all know that none of those predictions have come true. In fact, there is much more evidence showing that on balance, jobs are created and the economy expandsfollowing the passage of major reforms.

For example, the U.S. economy grew by 64 percent in the years following passage of the Clean Air Act. Furthermore, in a report to Congress on the costs and benefits of federal regulations, OMB estimated that major rules promulgated by the EPA between 2003 and 2013 had benefits between $165 billion and $850 billion, compared to costs of just $38 billion to $46 billion. That is a significant return on investment.

And however much we might wish for a world where big environmental issues are addressed voluntarily by industry or through the workings of the free market, we all know that it just does not work that way. Now, more than ever, the American people need a strong EPA to protect their right to clean air and water.

Let me be clear, I am not insensitive to some of the concerns we will likely hear today. But I want to remind everyone that the EPA—as required by law—must set the ozone standard at a level that will protect public health based on the science and not based on cost or technical feasibility. The health of Americans must come first. That said, I am confident, based on past precedents that ultimately these regulations act as a catalyst for the creation of new jobs and industrial sectors. Stricter pollutions limits force us to push the envelope of scientific innovation and create new technologies. According to the Department of Commerce, the United States is the world's largest producer of environmental protection technologies. Indeed at $782 billion, the market for environmental goods and services is comparable to the aerospace and pharmaceutical industries and presents important opportunities for U.S. industry.

Thankfully, poll after poll shows that the public agrees with me and believes that the EPA should protect their right to clean air and water more than they believe that pollution is the price they must pay for economic security.

Although significant progress has been made in the past 40 years, it is our job now to build upon this legacy and ensure that we continue to improve the quality of our air. A strong economy and a healthy environment are not mutually exclusive. The Clean Air Science Advisory Committee recommends lowering the ozone standard, and I think we should listen to our scientists. We can and must do better for current and future generations.

Thank you, Mr. Chairman, and yield back the balance of my time.

Chairman SMITH. Thank you, Ms. Johnson, and I will introduce our witnesses.

Our first witness is Mr. Harry Alford, the President, Chief Executive Officer, and co-founder of the National Black Chamber of Commerce. Mr. Alford put his leadership skills to work in a series of key sales and executive positions at Fortune 100 companies such as Proctor and Gamble, Johnson and Johnson, and the Sara Lee Corporation. He is also an active member of the Board of Directors of the U.S. Chamber of Commerce, where he chairs the Government Oversight and Consumer Affairs Committee. Mr. Alford attended the University of Wisconsin, and received top honors as Company Commander at the Army's Officer Candidate School.

Our next witness is Mr. Raymond Keating, the Chief Economist of the Small Business and Entrepreneurship Council. The Small Business and Entrepreneurship Council is a national non-partisan, non-profit advocacy organization that seeks to promote entrepreneurship and protect small business. Mr. Keating writes and speaks on a wide range of issues that impact the entrepreneurial sector of the economy. He received his Bachelor's Degree in Business Administration and Economics from St. Joseph's College, his Master's in Economics from New York University, and his MBA in Banking and Finance from Hofstra University.

Our next witness is Dr. Mary Rice, a pulmonary and critical care physician at Beth Israel Deaconess Medical Center at Harvard Medical School in Boston. At Beth Israel Deaconess Medical Center, Dr. Rice cares for patients with pulmonary diseases in clinic and in the hospital. In addition, she is a member of the Environmental Health Policy Committee of the American Thoracic Society. Dr. Rice spends the majority of her time engaged in epidemiologic research and studies, and health effects of day to day and long term air pollution exposure in large cohort studies of children and adults. Dr. Rice received her M.D. from Harvard University.

Our next witness is Dr. Allen S. Lefohn, President and Founder of A.S.L. and Associates. Dr. Lefohn has published over 125 peer reviewed publications, edited four books, and participated in a number of panel presentations. During his almost 50 year career, Dr. Lefohn has focused on understanding the relative importance of background ozone. He also developed exposure response relationships and indices that describe the effects of ozone on vegetation and human health, as well as the analysis of air quality data in biologically relevant forms for assessment purposes. Dr. Lefohn is an emeritus editor of the journal "Atmospheric Environment." He received his Ph.D. in physical chemistry from the University of California at Berkeley.

I will now yield to the gentleman from California, Mr. Knight, to introduce our final witness, Mr. Eldon Heaston, who is the Executive Director of the Mojave Desert Air Quality Management District and the Antelope Valley AQMD. And the gentleman from California is recognized.

Mr. KNIGHT. Thank you, Mr. Chair. It is an honor to introduce a constituent of mine. Eldon Heaston was appointed executive director of the Mojave Desert Air Quality Management District in March 2006. During his 23 years with the district, Heaston has worked to build and uphold its reputation as one of the most progressive and accessible air districts in the state. Before joining the district, Heaston spent over 11 years in the aerospace and petrochemical industry, where he held various positions in operations, industrial hygiene, and environmental management.

Heaston recently served six years as governor's appointee to the state's Inspection and Maintenance Review Committee, which evaluated the effectiveness of California's smog check program, and recommended program improvements. And I have a little bit of a connection to Eldon. My father created the Antelope Valley Air Quality Management District legislation in California. Mr. Heaston was very much a part of that, so, I thank you, Mr. Chair.

Chairman SMITH. Thank you, Mr. Knight. We will proceed with our testimony today. And, Mr. Alford, if you will begin?

TESTIMONY OF MR. HARRY C. ALFORD, PRESIDENT AND CEO, NATIONAL BLACK CHAMBER OF COMMERCE

Mr. ALFORD. Good morning, Chairman Smith, Ranking Member Johnson, and distinguished Members of the Committee on Science, Space, and Technology. My name is Harry C. Alford, and I am the President and CEO of the National Black Chamber of Commerce. The NBCC represents 2.1 million black owned businesses within the United States. I am here to testify about the Environmental Protection Agency's proposal to lower the ozone National Ambient Air Quality Standards.

Lowering the ozone standard, particularly to the level suggested by EPA, will almost certainly cause economic harm to the National Black Chamber of Commerce members, and will shut off huge parts of the country from economic development and job growth. As the country continues to recover from the recession, we should be finding ways to put Americans back to work, and to attract business here in the U.S. We should not be piling on yet another rushed, unreasonable regulation on the backs of American businesses.

As you are aware, last November EPA proposed lowering the primary ozone standard to a range of 65 to 70 parts per billion. Now the agency is taking comments on lower the standard down to 60 parts per billion. The current 75 parts per billion standard was finalized in March 2008. Significantly, that standard is being implemented. In fact, the EPA only finalized the implementation guidelines for the 2008 standard last month. The comment period for the new proposal closes today, and, under a court order, EPA must finalize the rule by October the 1st, 2015.

Last month the National Association of Manufacturers released an economic study by NERA Economic Consulting on the impacts of EPA lowering the ozone standard to 65 parts per billion. The study estimates that a 65 parts per billion standard would reduce the GDP by 140 billion, resulting in 1.4 million fewer jobs, and it costs the average U.S. household $830 in lost consumption each year, from 2017 to 2040.

One local area's business community is speaking out about feeling the negative impacts of the EPA ozone proposal. Baton Rouge, Louisiana, and the surrounding area, are home to many successful manufacturing and industrial facilities that help drive the economic livelihood of the area, and the country as a whole. In recent years, the state has worked hard to decrease ozone levels in Baton Rouge. Following a period of non-attainment, Baton Rouge was found to be in compliance with the current 75 parts per billion ozone standard in April 2014.

In 2014, the Baton Rouge area Chamber of Commerce worked with four chemical manufacturers who were investigating significant investments in the area. Two of the companies executed purchase agreements on sizable industrial locations, with the intent to develop them. Unfortunately, all four companies later decided to search elsewhere for their investments. The companies all indicated that EPA's ozone proposal, with the threat of the ozone standard being lowered, and the area falling back into non-attainment, influence their decisions to pull the plug on the projects in the Baton Rouge area.

In addition to the adverse economic impacts of the EPA's ozone proposal, those already being felt, and the ones being estimated, I would like to bring to the Committee's attention the following additional concerns that the National Black Chamber of Commerce has with the proposal. First, EPA should retain current 75 parts per billion ozone standard, and fully implement it. States didn't even find out which of their counties would be designated as non-attainment until the 2008 standard—under the 2008 standard until April 2012. Additionally, EPA did not finalize the necessarily implementation regulations and guidance for the 2008 standard until recently, in February 2015. States are committing time and money to meet the 2008 ozone standard, yet EPA now wants to move the goalposts in the middle of the game. This further strains what are already limited resources that states have for implementation, and fails to give states the chance to meet the current ozone standard.

Secondly, compliance with the new proposal standard may be unachievable. Many areas have high background levels of ozone from vegetation wildfires, transport of ozone from Asia, Mexico, and other places. These areas may not be able to meet the proposed standard, even with the most expensive controls. Notably, the Grand Canyon would fail the proposed 70 parts per billion standard, and Yellowstone National Park could not meet the proposed 65 parts per billion.

In conclusion, the NBCC and its members value and support clean air, clean water, and environmental quality. We also value and support economic growth, job creation, prosperity for our individual members, and this country as a whole. These are not mutually exclusive goals. We hope the EPA will hear the concerns of our organization and others, retain and fully implement the current 75 parts per billion standard. We appreciate the committee holding the hearing, and highlighting the critical issue. Thank you for the opportunity to testify. I look forward to answering your questions.

[The prepared statement of Mr. Alford follows:]

NBCC | National Black Chamber of Commerce®
4400 Jenifer St. NW Suite 331 | Washington, DC 20015
Office: 202-466-6888 | Fax: 202-466-4918
www.nationalbcc.org | info@nationalbcc.org

Congressional Hearing:

House Science, Space and Technology Committee

Honorable Lamar S. Smith, Chairman

Honorable Eddie Bernice Johnson, Ranking Member

“Reality Check: The Impact and Achievability on EPA’s Proposed Ozone Standards”

March 17, 2015

Presented By:

Harry C. Alford

President/CEO

Introduction

Good morning, Chairman Smith, Ranking Member Johnson, and distinguished Members of the Committee on Science, Space, and Technology. My name is Harry C. Alford and I am the President/CEO of the National Black Chamber of Commerce®. The National Black Chamber of Commerce represents 2.1 million Black owned businesses within the United States. I am here today to testify about the Environmental Protection Agency's proposal to lower the ozone National Ambient Air Quality Standard (NAAQS). Lowering the ozone standard, particularly to the levels suggested by EPA, will almost certainly cause economic harm to the National Black Chamber of Commerce members and will shut off huge parts of the country from economic development and job growth. As the country continues to recover from the recession, we should be finding ways to put Americans back to work and to attract business here in the U.S. We should not be piling on yet another rushed and unreasonable regulation on the backs of American businesses.

Background

As you are aware, last November, EPA proposed lowering the primary ozone standard to a range of 65 – 70 parts per billion (ppb). Now, the Agency is taking comments on lowering the standard down to 60 ppb. The current 75 ppb standard was finalized in March 2008. Significantly, that standard is still being implemented. In fact, EPA only finalized the implementation guidelines for the 2008 standard last month. The comment period for the new proposal closes on March 17 of this year, and under a court order, EPA must finalize the rule by October 1, 2015.

Economic Impacts

Last month, the National Association of Manufacturers released an economic study by NERA Economic Consulting on the impacts of EPA lowering the ozone standard to 65 ppb. The study estimates that a 65 ppb ozone standard would reduce the GDP by $140 billion, resulting in 1.4 million fewer jobs, and cost the average U.S. household $830 in lost consumption – each year from 2017 through 2040.

Local Impacts

These national economic numbers are certainly important, but I think it is also critical that we discuss the local impacts of the ozone standard generally and the EPA's proposal to lower it. It is the cities, counties and states that truly shoulder the burden and bear the brunt of the obligations and adverse impacts that stem from the continuous ratcheting down of the ozone standard. A designation of "nonattainment" – when an area is not meeting the ozone NAAQS – means no economic development, no new construction, and no job creation in that area. Specifically, in areas classified as in nonattainment, EPA can override state permitting decisions: such as upgrading new or existing facilities via the most effective emission reduction technologies without consideration of costs; and federally-supported highway and transportation projects can be suspended.

One local area's business community is speaking out about already feeling the negative impacts of EPA's ozone proposal.[1] Baton Rouge, Louisiana and the surrounding area are home to many successful manufacturing and industrial facilities that help drive the economic livelihood of the area and the country as a whole. In recent years, the state has worked hard to decrease ozone levels in Baton Rouge. Following a period of nonattainment, Baton Rouge was found to be in compliance with the current 75 ppb ozone standard in April 2014.

Meanwhile, Baton Rouge has been experiencing an economic boom in the last few years with a great deal of the U.S. manufacturing renaissance taking place there. The U.S. Bureau of Economic Analysis recently ranked Baton Rouge among the top ten of the nation's fastest-growing metropolitan areas with respect to percentage gains in gross domestic product.[2] In 2014, the Baton Rouge Area Chamber of Commerce worked with four chemical manufacturers, who were investigating significant investments in the area. Two of the companies executed purchase agreements on sizeable industrial locations with the intent to develop them. Unfortunately, all four companies later decided to search elsewhere for their investments. The companies all indicated that EPA's ozone proposal with the threat of the ozone standard being lowered and the area falling back into nonattainment influenced their decisions to pull the plug on the projects in the Baton Rouge area.

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[1] https://www.uschamber.com/sites/default/files/baton_rouge_area_chamber_ozone_naaqs_comments.pdf.

[2] *Id.*

Those four lost projects translated directly into lost dollars for the Baton Rouge area, its business community and its residents. According to the Baton Rouge Area Chamber, the projects would have resulted in **$86 million in wages annually** for the local economy. That dollar amount does not include any indirect investment or payroll that likely would have been created by the investments and project developments. Additionally, these projects would have included foreign investment – something that the U.S. is always eager to secure.

According to the Brookings Institution, Baton Rouge is among the twenty top-performing metropolitan economies in the country.[3] Of those top twenty metropolitan area economies, all but two of them would be in nonattainment were EPA to lower the ozone standard to 65 ppb.[4] In other words, the growth and development being experienced by some of our country's most economically prosperous areas right now are being threatened by EPA's ozone proposal. The four lost projects in Baton Rouge are only the tip of the iceberg. Without a doubt, there have been others, and there will be more.

Additional Criticisms of Proposal

In addition to the adverse economic impacts of the EPA's ozone proposal – those already being felt and the ones being estimated – I would like to bring to the Committee's attention the following additional concerns that the National Black Chamber of Commerce has with the proposal:

First, EPA should retain the current 75 ppb ozone standard, and fully implement it. States did not even find out which of their counties would be designated as in nonattainment under the 2008 standard until April 2012. Additionally, EPA did not finalize the necessary implementation regulations and guidance for the 2008 standard until just recently in February 2015. States are committing time and money to meet the 2008 ozone standard. Yet EPA now wants to move the goal posts in the middle of the game. This further strains what are already limited resources that states have for implementation, and fails to give states a chance to meet the current ozone standard.

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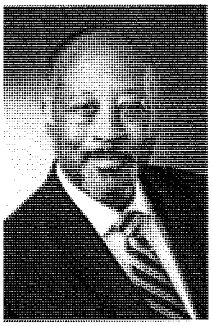
[3] http://www.brookings.edu/research/interactives/metromonitor#/M10420

[4] http://www.brac.org/brac/news_detail.asp?article=1947.

Secondly, compliance with the new proposed standard may be unachievable. Many areas have high "background" levels of ozone from vegetation, wildfires, and transport of ozone from Asia, Mexico and other places. These areas may not be able to meet the proposed standard even with the most expensive controls. Notably, the Grand Canyon would fail the proposed 70 ppb standard, and the Yellowstone National Park could not meet the proposed 65 ppb standard.

Conclusion

The National Black Chamber of Commerce and its members value and support clean air, clean water, and environmental quality. We also value and support economic growth, job creation, and prosperity for our individual members and this country as a whole. These are not mutually exclusive goals. We hope that EPA will hear the concerns of our organization and others, and retain and fully implement the current 75 ppb standard. We appreciate the Committee holding this hearing and highlighting this critical issue. Thank you for the opportunity to testify and I look forward to answering any questions you may have.



Harry C. Alford
President & CEO

For these last twenty years, NBCC President/CEO and co-founder Harry C. Alford has established himself as perhaps the nation's preeminent champion of African American business empowerment. From a visionary concept of what Blacks need to do to fully seize their place in the economic mainstream, Mr. Alford has built a global organization that has earned a place at the table in the White House and at the top levels of Corporate America.

As the intellectual and spiritual linchpin of the NBCC, Mr. Alford has been responsible for opening doors that have led to billions of dollars in new business for Black owned firms throughout the nation. His courage and leadership have been noted by all in the rebuilding of the Gulf Coast in the aftermath of Hurricane Katrina. His relentless energy and advocacy is helping forge international business opportunities for African Americans and emerging entrepreneurs in Africa, the Caribbean, South America and the rest of the African Diaspora. For this work he was formally named a Cultural Ambassador by the US State Department. A native of California, Mr. Alford has made his mark at the highest levels of both the private and public sectors. He matriculated at the University of Wisconsin via an athletic scholarship (football). After earning top honors as Company Commander in the Army's Officer Candidate School class (OC3-72), Mr. Alford put his leadership skills to work in a series of key sales and executive positions at Fortune 100 companies such as Procter & Gamble, Johnson & Johnson and the Sara Lee Corporation. Mr. Alford has led large trade missions to Brazil, Ghana, Kenya and various nations in the Caribbean. Recently, he helped establish the French African Diaspora Chamber of Commerce in Paris, France. The birth and growth of the National Black Chamber of Commerce is consistent with the dynamic growth of African American owned firms in the United States – the fastest growing segment in the nation per the US Census Bureau.

Mr. Alford is an award winning columnist for the National Newspaper Publishers Association and consults and speaks on business matters to groups and agencies throughout the nation. He proudly served on the NNPA Foundation Board of Directors. He is an active member of the Board of Directors of the US Chamber of Commerce where he chairs the Government Oversight and Consumer Affairs Committee. He is a member of the 2008 Health Sector Assembly which is a think tank of national leaders concerned about healthcare. As a consultant, he has developed business models tailored to specific corporations and public agencies. Mr. Alford is regularly called upon by Congress to testify on various legislative initiatives related to small business development, the Gulf Coast rebuilding, e-commerce, healthcare, energy, tax reform and global trade issues. He received national recognition while delivering testimony concerning the recent Cap and Trade Energy debate. He was inducted into the Oxnard High School Hall of Fame in 2013. Mr. and Mrs. Alford reside in Virginia and have two sons who were scholar athletes at the University of Maryland (lacrosse).

Chairman SMITH. Thank you, Mr. Alford.

Mr. Keating?

TESTIMONY OF MR. RAYMOND KEATING, CHIEF ECONOMIST, SMALL BUSINESS & ENTREPRENEURSHIP COUNCIL

Mr. KEATING. Mr. Chairman, Ranking Member Johnson, Members of the Committee, thank you for hosting this important hearing today on the Environmental Protection Agency's proposed ozone standards. My name is Raymond Keating. I am Chief Economist with the Small Business and Entrepreneurship Council. We are a non-partisan, non-profit advocacy, research, and training organization dedicated to protecting small business, and advancing entrepreneurship. We have nearly 100,000 members, and we work with some 250,000 small business activists across the country.

Regarding the EPA's proposal, SB Council is concerned about the considerable costs involved with these new regulations, including the resulting impact for entrepreneurship and small business. My testimony touches on three important points, the realities of regulation, economic costs in non-attainment, and disproportionate impact on small business and new business formation.

In terms of the realities of regulation, as we look at the EPA's proposal, it must be made clear that the costs of regulations are real and significant facts of economic life, about which small businesses are painfully aware. Some policymakers seem unconcerned or dismissive about regulatory costs, even claiming that such government mandates and rules spur innovation, and related job gains. This view of regulation is very trouble.

Economics 101 makes clear what to expect from increased regulation, that is higher costs for businesses and consumers, reduced market exchanges, and expanded political controls, resources allocated based on political decisions and influences, rather than via competition and consumer sovereignty, and, therefore, diminished economic growth. The tremendous amount of resources funneled into dealing with government regulation are not about innovation and new jobs, as some assert. Rather, they are about massive opportunity costs. That is, effectively, what is lost because resources must be used for complying with government regulations.

In fact, the costs of regulation have been confirmed in an assortment of studies, such as the significant losses in economic growth, for example two percentage points lost annually on average due to federal regulation over several decades, as reported by economist John Dawson at Appalachian State University, and John Cedar at North Carolina State University. The $1.9 trillion cost of federal regulation annually, noted by Clyde Wayne Crews in his report "Ten Thousand Commandments", and the disproportionate burden of federal regulations on small businesses, as explained by a series of studies from the Small Business Administration's Office of Advocacy.

Number two, on economic costs and non-attainment, the EPA's proposed ozone regulations promise to be no different in terms of imposing costs, except for the fact that these have been identified by many as being potentially the most costly federal regulations ever imposed. The NERA study has already been referenced, so I won't touch on that right now, but those numbers are certainly significant. And as NERA, the Business Roundtable, the American Chemistry Council and others show, significant portions of the nation are in non-attainment under the current ozone standards. That will expand significantly under the proposed EPA mandate.

As for the disproportionate impact on small business, when you are talking about all sectors of the economy being negatively affected, directly or indirectly, by the EPA's new regulation, small business will be hit hardest, as is the case with nearly all regulations, and given that small businesses account for the overwhelming majority of firms across our economy. I will just cite a few industries very quickly that were noted in the NERA study to have negative impact.

Among manufacturing firms, 75 percent have less than 20 workers. Among key energy industries, 91 percent of employers in the oil and gas extraction businesses have less than 20 workers. 82 percent of the support activities for oil and gas operations, less than 20 workers. 59 percent of coal mining firms actually have less than 20 workers. And 65 percent of support activities for coal mining, less than 20 workers. Chemical manufacturing, 62 percent, again, less than 20 workers, so this is clearly about small business.

Small business in non-attainment areas will have a difficult time starting up, expanding, and competing for offsets, as those offsets will be expensive, or perhaps not exist when needed. Compliance will be complex and costly. Economic opportunity and job creation will suffer. The expense and red tape will be a barrier to new startups and business formations. These regulations would hamper local efforts to spur new business creation, and could, in effect, serve as a cap on entrepreneurship and small business growth.

Given what has already been achieved, what has not yet been implemented, and the significant costs, including for small business, that would come with stricter ozone mandates, one is left bewildered as to why the EPA is going down this path.

Thank you for the opportunity to testify today, and I look forward to your questions.

[The prepared statement of Mr. Keating follows:]

SBE
COUNCIL
Small Business & Entrepreneurship Council

Small Business, the Economy and Regulatory Realities in Light of EPA's Proposed Ozone Standards

Testimony by
Raymond J. Keating
Chief Economist
Small Business & Entrepreneurship Council
and the
Center for Regulatory Solutions

Before the
Committee on Science, Space, and Technology
U.S. House of Representatives

The Honorable Lamar S. Smith, Chairman
The Honorable Eddie Bernice Johnson, Ranking Member

March 17, 2015

301 Maple Avenue West • Suite 100 • Vienna, VA 22180 •(703)-242-5840
sbecouncil.org • @SBECouncil

Protecting Small Business, Promoting Entrepreneurship

Chairman Smith, thank you for hosting this important hearing today on the Environmental Protection Agency's (EPA) proposed ozone standards.

The Small Business & Entrepreneurship Council (SBE Council), along with its Center for Regulatory Solutions, is pleased to submit this testimony.

My name is Raymond Keating, and I am the chief economist for SBE Council, as well as serving as an adjunct professor in the Townsend Business School at Dowling College where I teach a variety of courses in the MBA program; a weekly newspaper columnist for *Long Island Business News*; and author of several books, with the latest being *Unleashing Small Business Through IP: Protecting Intellectual Property, Driving Entrepreneurship.*

SBE Council is a nonpartisan, nonprofit advocacy, research and training organization dedicated to protecting small business and promoting entrepreneurship. With nearly 100,000 members and 250,000 small business activists nationwide, SBE Council is engaged at the local, state, federal and international levels where we collaborate with elected officials, policy experts and business leaders on initiatives and policies that enhance competitiveness and improve the environment for business start-up and growth. The Center for Regulatory Solutions is a project of SBE Council.

On November 25, 2014, the EPA proposed to tighten the National Ambient Air Quality Standards (NAAQS) pertaining to ozone. The new regulation would reduce the standard from the 75 parts per billion (ppb) – which was set in 2008, down from 84 ppb – to a range of 65 to 70 ppb, with the agency seeking comments on a regulation as low as 60 ppb.

We at SBE Council are concerned about the considerable costs involved with these new regulations, including the resulting impact for entrepreneurship, small business and the economy. This testimony touches on three important points: 1) the realities of regulation, 2) economic costs and nonattainment under the EPA proposed ozone regulations, and 3) the proposed ozone regulations disproportionate impact on small business and new business formation.

The Realities of Regulation

As we look at the EPA's proposal to tighten the NAAQS pertaining to ozone, it must be made clear that the costs of regulations are real and significant facts of economic life about which small businesses are too often painfully aware.

Despite real and significant costs, some policymakers seem unconcerned or dismissive about regulatory costs. Indeed, some who call for increased regulation actually claim that such government mandates and rules spur innovation and related job gains. This view of regulation is troubling.

Economics 101 makes clear what to expect from increased regulation – that is, higher costs for businesses and consumers, reduced market exchanges and expanded political control, resources allocated based on political dictates and influences (such as rent seeking) rather than via competition and consumer sovereignty, and therefore, diminished economic growth.

The tremendous amounts of resources funneled into dealing with government regulatory dictates are not about innovation and new jobs. Rather, they are about massive opportunity costs, that is, effectively what is lost because resources must be used for complying with government regulations.

Again, some pro-regulation advocates will actually claim that regulations imposed in the past have cost the U.S. economy little or nothing. They not only ignore what would have happened absent those regulations, but also the simple economic fact that increased regulations on businesses mean that business costs increase, that is, as taught in Economics 101, the firm's cost curve shifts upward.

Economists John Dawson at Appalachian State University and John Seater at North Carolina State University recently looked at the impact of federal regulation on economic growth ("Federal Regulation and Aggregate Economic Growth," January 2013). The authors point to a dozen previous studies performed looking at the impact of regulation on the macroeconomy, noting, "Almost all these studies conclude that regulation has deleterious effects on economic activity." Dawson and Seater's findings certainly were striking. They reported: "We find that regulation has statistically and economically significant effects on aggregate output and the factors that produce it–total factor productivity (TFP), physical capital, and labor. Regulation has caused substantial reductions in the growth rates of both output and TFP and has had effects on the trends in capital and labor that vary over time in both sign and magnitude."

Specifically:

> "Regulation's overall effect on output's growth rate is negative and substantial. Federal regulations added over the past fifty years have reduced real output growth by about two percentage points on average over the period 1949-2005. That reduction in the growth rate has led to an accumulated reduction in GDP of about $38.8 trillion as of the end of 2011. That is, GDP at the end of 2011 would have been $53.9 trillion instead of $15.1 trillion if regulation had remained at its 1949 level."

The authors added:

> "Our results are qualitatively consistent with those obtained from studies using the various cross-country and panel data sets on regulation. Quantitatively, our estimated impact of regulation on aggregate output, large as it is, is similar to or lower than the micro-level impacts estimated in the cross-country and panel data studies. The cross-country and panel data are constructed very differently from our data, covering a subset of total regulations but over an array of countries. It thus seems that regulation has strong and robust negative effects on aggregate output."

Of course, there is much more on the costs of regulation beyond the Dawson and Seater study, and the dozen studies they note. For example, in "Ten Thousand Commandments: An Annual Snapshot of the Federal Regulatory State, 2014 Edition," Clyde Wayne Crews Jr. reported: "The estimated cost of regulation exceeds half the level of the federal budget itself. Regulatory costs of $1.863 trillion amount to 11.1 percent of the U.S. gross domestic product (GDP), which was estimated at $16.797 trillion in 2013 by the Bureau of Economic Analysis." That's a serious drain and drag on the private sector. To put this in perspective, Crews noted: "U.S. households 'pay' $14,974 annually in regulatory hidden tax, thereby 'absorbing' 23 percent of the average income of $65,596, and 'pay' 29 percent of the expenditure budget of $51,442. The 'tax' exceeds every item in the budget except housing. More is 'spent' on embedded regulation than on health care, food, transportation, entertainment, apparel and services, and savings."

For good measure, the Small Business Administration's Office of Advocacy periodically estimates regulatory costs, obviously with an eye towards the burdens imposed on smaller businesses. In September 2010, the Office of Advocacy published an updated study estimating the costs of complying with federal regulations. The study – "The Impact of Regulatory Costs on Small Firms" by Nicole V. Crain and W. Mark Crain from Lafayette College – provided details regarding the burdens of federal regulatory costs. For example:

- The annual cost of federal regulations registered $1.75 trillion in 2008.

- For firms with less 20 employees, the per-employee cost registered $10,585, which was 42% higher than the $7,454 per employee cost for firms with 20-499 employees, and 36% higher than the $7,755 for firms with 500 or more employees.

- On the environmental front, per employee regulatory costs for firms with less than 20 employees came in at $4,101, which topped the $1,294 cost for firms with 20-499 employees by 217% and the $883 cost for businesses with 500 or more workers by 364%.

- Small manufacturers get hit particularly hard. Per employee regulatory costs for manufacturers with fewer than 20 employees came in at $28,316, which was 110% higher than the $13,504 for manufacturers with 20-499 employees and 125% more than the $12,586 burden on companies with 500 or more employees. Again, serious cost differentials came in the area of environmental regulation, where per employee costs for manufacturers with fewer than 20 employees came in at $22,594, which topped the $7,131 for firms with 20-499 employees by 217% and exceeded the $4,865 for firms with 500 or more workers by 364%.

Of course, it needs to be pointed out that small and mid-size businesses – that is, those with less than 500 workers – are central to economic growth and job creation. As the SBA's Office of Advocacy has summed up ("Frequently Asked Questions About Small Business," March 2014), small businesses account for 46 percent of private-sector output, and 98 percent of firms exporting goods. As for jobs: "Small firms accounted for 63 percent of the net new jobs created between 1993 and mid-2013 (or 14.3 million of the 22.9 million net new jobs). Since the end of the recession (from mid-2009 to mid-2013), small firms accounted for 60 percent of the net new jobs. Small firms in the 20-499 employee category led job creation."

So, it is imperative to keep our thinking clear on the effects of regulation. Those effects certainly are not about being a spur to innovation and job creation, but in reality, just the opposite, as resources are drained away from market, private-sector inventions, innovation, and investments, and redirected according to political preferences.

Economic Costs and Nonattainment Under Proposed EPA Ozone Regulations

The EPA's proposed ozone regulations promise to be no different in terms of imposing costs, except for the fact that these have been identified as being potentially the most costly federal regulations ever imposed.

In late February, NERA Economic Consulting updated a comprehensive study ("Economic Impacts of a 65 ppb National Ambient Air Quality Standard for Ozone") of these EPA ozone regulations for the National Association of Manufacturers, assessing the economic impact of a 65 ppb NAAQS for ozone. Again, and unsurprisingly, the costs would be significant. Consider (with all dollar costs noted in real 2014 dollars) seven key findings from the study:

> **1. Lost Output and Jobs.** "Employing our integrated energy-economic macroeconomic model (NewERA), we estimate that the potential emissions control costs could reduce U.S. Gross Domestic Product (GDP) by about $140 billion per year on average over the period from 2017 through 2040 and by about $1.7 trillion over that period in present value terms. The potential labor market impacts represent an average annual loss employment income equivalent to 1.4 million jobs (i.e., job-equivalents)."

2. Reduced Household Consumption. "Average annual household consumption over those same years could be reduced by an average of about $830 per household per year."

3. The Full Labor Picture. "A loss of one job-equivalent does not necessarily mean one less employed person—it may be manifested as a combination of fewer people working and less income per worker. However, this measure allows us to express employment-related impacts in terms of an equivalent number of employees earning the average prevailing wage. These are the net effects on labor and include the positive benefits of increased labor demand in sectors providing pollution control equipment and technologies."

4. Higher Energy Prices. "Emissions reduction costs of a 65 ppb ozone standard also is likely to have impacts on U.S. energy sectors, largely because the more stringent ozone standard is projected to lead to the premature retirement of many additional coal-fired power plants... The average delivered residential electricity price is projected to increase by an average of 1.7% over the period from 2017 through 2040 relative to what they could otherwise be in each year (which is projected to be rising even without a tighter ozone NAAQS). Henry Hub natural gas prices are projected to increase by an average of 3.7% in the same time period (again, relative to what they could otherwise be in each future year), while delivered residential natural gas prices could increase by an average of 3.7%. Part of the increase in delivered natural gas prices reflects the increase in pipeline costs due to control costs for reductions in NOX emissions in the pipeline system that could be recovered through tariff rates."

5. Not the Complete Cost Story. It also must be noted that this latest analysis is not as complete at the study NERA published in July 2014. Time constraints did not allow for an updated analysis of how energy production could be affected in rural areas. As noted in the February 2015 report summary: "A tightened ozone standard has the potential to cause nonattainment areas to expand into relatively rural areas, where there are few or no existing emissions sources that could be controlled to offset increased emissions from new activity. If nonattainment expands into rural areas that are active in U.S. oil and gas extraction, a shortage of potential offsets may translate into a significant barrier to obtaining permits for the new wells and pipelines needed to expand (or even maintain) our domestic oil and gas production levels. The sensitivity analysis in our July 2014 report resulted in much larger natural gas price effects, and raised macroeconomic impacts of our base case by about 30 to 50%. Limitations of time have prevented us from conducting a similar sensitivity analysis for this update."

Nonetheless, it is noted in the most recent NERA findings: "In total, the costs of complying with the rule from 2017–2040 could top $1 trillion, making it the most expensive regulation ever issued by the U.S. government." It also must be pointed out, as noted in the report, "All sectors of the economy would be affected by a 65 ppb ozone standard, both directly through increased emissions control costs and indirectly through impacts on affected entities' customers and/or suppliers."

6. NERA vs. EPA Costs. As opposed to the EPA's essential guesswork on costs, the NERA study attempts to get at the real potential costs based on the realities of the marketplace. As noted, "As in the July 2014 analysis, emission reductions from 'known' controls were not sufficient to achieve attainment, in this case with a 65 ppb ozone standard. EPA has filled the gap with a rough estimate of costs of 'unknown' controls, i.e., controls for which no cost information was developed. In contrast to the two cost estimation methodologies presented in its 2008 and 2010 RIAs, this time EPA used a single simplistic assumption that annualized control costs for these 'unknown' controls would be equal to $15,000 per ton, regardless of the state, the sector, or the amount of emission reduction required. This estimate was not based upon any evidence-based analyses of the nature of the emissions that remain after 'known' controls are in place, or of the costs of potential additional controls for these sources. Our compliance cost estimates are based upon a synthesis of EPA estimates of emission reduction, our modifications of EPA's assumptions regarding baseline reductions, EPA's estimates of the costs of 'known' controls, and our more detailed estimates of the costs of 'unknown' controls. As in our July 2014 report, our 'unknown' cost estimates are more evidence-based than EPA's, as we use detailed information on the types of sources that account for the remaining emissions (EGUs, other point sources, on-road sources, off-road mobile sources, and area sources) as well as estimates of the potential costs of reducing emissions by scrapping existing emission sources prematurely."

And later in the report: "We estimate that the potential costs of achieving a 65 ppb ozone standard could have a present value of almost $1.1 trillion as of 2014 (based upon costs incurred from 2017 through 2040), not including any costs for forcing a massive cutback in generation from coal-fired EGUs to reduce NOX emissions from the power sector (whose costs are endogenously determined in the economic impact model)… As a rough point of comparison, we estimate that EPA's annualized cost estimate implies a present value of about $167 billion. The primary difference in our methodologies is the extrapolation method used to estimate the cost of 'unknown' controls; we attempted to assess the kinds of controls that would be required after "known" controls and based our method on the estimated costs per ton of one such control (vehicle scrappage), whereas EPA relied on an arbitrary constant value."

7. Implications for Economy-Wide Nonattainment. As explained in the initial comprehensive economic study from NERA published in July 2014 ("Assessing Economic Impacts of a Stricter National Ambient Air Quality Standard for Ozone"), the problems that come with nonattainment are considerable: "Unlike regulations that target specific sectors, an ozone standard would directly affect virtually every sector of the economy, because ozone precursors (oxides of nitrogen, or NOX, and many types of volatile organic compounds, or VOCs) are emitted by a wide range of stationary, mobile, and area sources. Moreover, a tightened standard might result in other effects, notably potential constraints on domestic natural gas and crude oil development activity if nonattainment regions introduce permitting barriers or require emissions offsets to develop new wells and processing facilities."

The July 2014 report also explained what "non-attainment" means in practical terms, that is, new businesses must obtain air permits to operate. As NERA stated: 'Finally, being in nonattainment of a NAAQS triggers more regulatory burdens than just reducing emissions to achieve attainment. A number of regulatory programs are also imposed on nonattainment areas. Significant among these is a requirement that any economic entity that wishes to obtain a permit to establish a new facility that will emit the pollutant(s) of concern in a nonattainment area must first find an offsetting reduction of those same emissions from another facility that is exiting the area, or has voluntarily reduced its owu emissions below its permitted level. Markets for these 'offsets' often develop, but offsets can be

> exceedingly costly or difficult to find if there are few existing emitting facilities in the area to create a supply. A tightened ozone standard has the potential to cause nonattainment areas to expand into relatively rural areas, where there are few or no existing manufacturing facilities to generate a supply of offsets. If nonattainment expands into rural areas that are active in U.S. oil and gas extraction, a shortage of offsets may translate into a significant barrier to obtaining permits for the new wells and pipelines needed to expand (or even maintain) our domestic oil and gas production levels."

Much of the nation would be in nonattainment areas under the EPA's new regulatory standards. For example, the Business Roundtable has reported ("EPA Current and Proposed Ozone Standards" on their website at http://businessroundtable.org/ozone-map.): "155 U.S. counties violate the current ground-level ozone standard of 75 parts per billion (PPB). EPA is considering a new standard in the range of 70 ppb to 60 ppb… Approximately one-third of the U.S. population currently lives in areas that violate the current standard of 75 ppb." At 70 ppb, based on the Business Roundtable's analysis, 48 percent of the population would live in counties at risk of violating the ozone standard, and 45 percent of manufacturing jobs would be located in such counties. At 65 ppb, it would be 59 percent of the population living in counties risking violation, and 58 percent of manufacturing jobs.

The American Chemistry Council also looked at nonattainment and costs (see "EPA's ozone standard: A defining moment for U.S. manufacturing," March 9, 2015, at http://blog.americanchemistry.com/2015/03/epas-ozone-standard-a-defining-moment-for-u-s-manufacturing/#sthash.BfHzy2Uu.dpuf). According to the CCA, investment in new and expanded facilities will suffer in nonattainment areas: "In nonattainment areas, total emissions are capped. Business growth becomes a zero-sum game: In order to expand, companies must shut down other parts of their production, wait for others to close, or buy emissions 'offsets' that are difficult to find and extremely expensive. All these factors create uncertainty in investment projects that can ultimately make new investment not worth the trouble… For factories and power plants, a lower ozone standard means new facilities, expansions, and restarts could be delayed or scrapped. Facilities that do expand will have to pay millions for offsets even though their new production is cleaner and state of the art." That effectively is a cap on new business formation and business and economic growth.

The CCA highlighted chemistry industry investments happening in the state of Louisiana thanks to lower costs via the shale natural gas revolution. But these investments are at risk: "So far, 51 projects representing $35 billion in new investment are planned for the state. The projects would generate $21.5 billion in additional chemical industry output and 37,200 permanent new jobs (direct + indirect). Most of Louisiana would be in nonattainment at 65 ppb. By lowering the NAAQS, EPA could limit the vast economic potential of these historic investments."

As for how extensive nonattainment would be, the CCA noted: "At 65 ppb, which is at the lower end of the range EPA proposed, 2000 counties in 45 states covering a population of 255 million would be in nonattainment, based on EPA's most recent complete air quality data. At 70 ppb, 1300 counties in 40 states covering a population of 210 million would be in nonattainment."

Finally, the CCA also highlighted the impact on small business: "Small businesses such as gas stations, bakeries, printing operations, dry cleaners, auto body shops and small manufacturers will be affected."

Disproportionate Impact on Small Businesses

In the end, all sectors of the economy would be negatively affected by the EPA's new, stringent NAAQS ozone regulations. That means, of course, that small businesses will be hit hardest, as is the case with nearly all regulations and given that small businesses account for the overwhelmingly majority of firms across nearly all sectors of our economy.

The NERA study highlighted potential lost output in non-energy and energy sectors. Consider the major role small business plays in the overall economy and in some of these key sectors affected by these new regulations (latest Census Bureau employer data from 2012):

• Among all industries, 89.6% of employer firms have less than 20 workers, and 99.7% less than 500 employees.

• Among agriculture, forestry, fishing and hunting businesses, 93.5% of employer firms have less than 20 workers, and 99.6% less than 500 workers.

• Among all manufacturing firms, 75.3% have less than 20 workers, and 98.6% less than 500 employees.

• Among key energy industries:

  - 90.7% of employer firms among oil and gas extraction businesses have less than 20 workers, and 98.5% less than 500 workers;
  - 78.1% of firms among drilling oil and gas wells businesses have less than 20 workers, and 97.2% less than 500 workers;
  - 81.5% of firms among support activities for oil and gas operations businesses have less than 20 workers, and 98.6% less than 500 workers;
  - 60.5% of firms among oil and gas pipeline and related structures construction businesses have fewer than 20 workers, and 95.5% less than 500 workers;
  - 54.7% of firms among oil and gas field machinery and equipment manufacturing businesses have less than 20 workers, and 91.4% less than 500 workers;
  - 58.5% of firms among coal mining firms have less than 20 workers, and 93.7% less than 500 workers;
  - and 64.6% among support activities for coal mining businesses have fewer than 20 employees, and 96.4% less than 500 workers.

And what about chemical industries, given their concerns, as noted above?

• As for chemical manufacturing, 62.4% of employer firms have less than 20 workers, and 94% have less than 500 employees.

• Among chemical and allied products merchant wholesalers, 83.3 percent of employer firms have fewer than 20 employees, and 97.4% less than 500 workers.

Again, this very much is about small business.

The costs of the proposed EPA ozone regulations promise to be enormous for small businesses, and for the overall economy. It's also worth highlighting that energy – which has been a rare bright spot in an otherwise dismal economy over the past eight years – and manufacturing – which is in the midst of a revitalization – would both suffer significantly under the new EPA regulations. Again, these are small-business sectors.

Conclusion

Small businesses in non-attainment areas will have a difficult time starting up, expanding and competing for "offsets," as those offsets will be expensive, or perhaps not exist when needed. Compliance will be complex and costly. Economic opportunity and job creation will suffer. The expense and red tape will be a barrier to new startups and business formation. These regulations would hamper local efforts to spur new business creation, and could, in effect, serve as a cap on entrepreneurship and small business growth.

Indeed, the proposed ozone rule not only has the potential to be the "most expensive regulation" ever enacted by the federal government in U.S. history, it will be one that severely impinges on entrepreneurship and economic freedom.

The CCA, along with many others, by the way, have made the important point that the "current ozone standard of 75 ppb is the most stringent ever and hasn't been fully implemented across the country," as "parts of 26 states covering a population of 120 million still don't meet the current standard." And to put all of this in broader perspective, "Between 1980 and 2013, total emissions of the six principal air pollutants dropped by 62 percent, even as U.S. gross domestic product grew 145 percent. Voluntary and regulatory programs will continue to reduce ozone concentrations through 2030."

Given what's already been achieved, what has not yet been implemented, and the significant costs, including for small business, that would come with stricter ozone mandates, one is left bewildered as to why the EPA is going down this path.

Thank you for the opportunity to testify today.

Raymond J. Keating serves as chief economist with the Small Business & Entrepreneurship Council (SBE Council), a nonpartisan, nonprofit small-business advocacy group.

He writes, speaks and testifies on a wide range of issues affecting the entrepreneurial sector of the economy. In addition to policy papers and reports, he pens the weekly SBE Council Cybercolumn, Fact of the Week, Capital & Credit analysis, Technology & IP analysis, and Energy & Entrepreneurs analysis for SBE Council's website www.sbecouncil.org.

Keating also writes a weekly column for *Long Island Business News*. Previously, for more than 11 years, he wrote a column for *Newsday* on Long Island.

In addition, Keating is an adjunct professor/lecturer in the business school at Dowling College.

Keating has written five nonfiction books – *Unleashing Small Business Through IP: Protecting Intellectual Property, Driving Entrepreneurship* (2013), *"Chuck" vs. the Business World: Business Tips on TV* (2011), *U.S. by the Numbers: What's Left, Right, and Wrong with America State by State* (2000), *New York by the Numbers: State and City in Perpetual Crisis* (1997), and *D.C. by the Numbers: A State of Failure* (1995). He also has contributed essays to four other books, and penned four novels.

Keating has written hundreds of articles, with pieces published in such periodicals as *The Washington Post, The Wall Street Journal, The New York Times, Boston Globe, National Review, Investor's Business Daily, Chicago Tribune, The Washington Times, New York Post, Daily News,* and many more.

His areas of expertise include taxation; federal, state and city budget issues; monetary policy; regulation; energy policy; supply-side economics; the economics of sports stadiums and arenas; the U.S. economy; trade; and a host of other small-business issues.

Keating holds an MA in economics from New York University, an MBA in banking and finance from Hofstra University, and a BS in business administration and economics from St. Joseph's College.

Chairman SMITH. All right. Thank you, Mr. Keating.

Dr. Rice?

TESTIMONY OF DR. MARY B. RICE, INSTRUCTOR IN MEDICINE, HARVARD MEDICAL SCHOOL, PULMONARY AND CRITICAL CARE PHYSICIAN, DIVISION OF PULMONARY, CRITICAL CARE AND SLEEP MEDICINE, BETH ISRAEL DEACONESS MEDICAL CENTER, BOSTON MA

Dr. RICE. Thank you, Mr. Chairman. I am Dr. Mary Rice. I am a pulmonary and critical care physician at Beth Israel Deaconess Medical Center at Harvard Medical School, and I care for adults with lung disease, many of whom suffer from asthma and Chronic Obstructive Pulmonary Disease, known as COPD. You have my written testimony before you, and there are just a few points that I would like to add to the discussion.

First, ozone is bad for people with lung disease, and this has been known for decades. Ozone is a power oxidant that irritates the lung tissue, and damages the lung. Hundreds of research studies in different areas across the U.S. and around the globe have demonstrated that when people with common disease, like asthma and COPD, are exposed to ozone, they get sick.

One of my patients with severe asthma tells me that on those hot ozone days in the summertime, he feels his chest tighten up, and he feels like he cannot get enough air. He stays home from work, and he uses his inhaler around the clock, but that is not enough, and that is when he calls me, asking for stronger medications. One summer his breathing difficulties were so severe that he was hospitalized twice in one summer.

Now, this is just one story, but hundreds have studies have demonstrated that increases in ozone are associated with people having to increase the use of medications to control asthma, having to miss school or work to visit the doctor because their medications aren't strong enough, going to the emergency room for respiratory symptoms, and hospitalization for respiratory illness. And for some, especially the most vulnerable people, such as the elderly and people with COPD, high ozone days result in premature death.

Second, what sometimes gets lost is that ozone pollution is a respiratory irritant for otherwise healthy people too, and research, including my own work in the Framingham Heart Study with my colleagues at the Harvard School of Public Health, has shown that when normal healthy adults are exposed to ozone levels above 60 parts per billion, their lungs do not function as well as when the ozone level is below 60.

And, third, it doesn't matter where the ozone comes from, whether it is background ozone, transport ozone from other countries, ozone created by pollution right here in the U.S., our lungs can't tell the difference. Ozone is harmful to our lungs regardless of its source, and it is especially dangerous for people with lung disease.

Fourth, when people in the medical community talk about ozone's impact on public health, what we are really talking about is the accumulation of all the personal stories that make up America. And I am sure that many people in this room have personal stories involving respiratory diseases because they are just so common. I am a physician and a researcher, but my most important job is my role as a mother to three children under the age of six, and one of them, my 1-year-old son, has had two emergency room visits and one hospitalization for respiratory disease.

Ozone has been found to increase the risk of emergency room visits for respiratory infection in young children under the age of four, and when my son develops a cough, I am terrified that this could mean the next ambulance ride. And when he is sick, I cannot go to work, I can't take care of my patients, or my husband can't go to work, or we have to leave our sick child home with a caretaker. But we are more fortunate than many Americans, some of whom risk losing their job, or struggle to pay for the emergency room visit when they or a loved one suffers and acute respiratory illness, such as an asthma attack.

Ozone above 60 parts per billion is harmful to public health. It increases my son's risk of the next hospital visit. Nationwide, ozone levels above 60 have been estimated to increase the number of acute respiratory illnesses by 10 million per year in the United States. My son, and every American, deserve an ozone standard that is protective.

Lastly, the science is strong and compelling. Since 2006, when the Bush Administration EPA looked at the ozone standard, the American Thoracic Society recommended a more protective standard, 60 parts per billion. We were confident of our recommendation then, and we are more confident of our recommendation today. The more scientists and doctors have studied the health effects of ozone, the more confident the medical community has become about ozone's harmful effects on the respiratory health of children, adults, and the elderly.

And the EPA is not basing their proposed standard on one study or 10 studies. The proposed rule is based on literally hundreds of studies that demonstrate that the current standard is not protective. These studies include multiple scientific methods, including animal toxicology studies, human exposure studies, observational epidemiology studies, natural experiment studies, meta-analyses that combine the results of multiple studies, and the evidence overwhelmingly indicates that the current ozone is not protective of public health, and that levels in the range of 60 to 75 parts per billion are harming people with lung disease.

On behalf of the American Thoracic Society, I urge the EPA and the Administration to finalize a more protective ozone standard of 60 parts per billion. I would be happy to take questions. Thank you.

[The prepared statement of Dr. Rice follows:]

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Suite 300
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P. (202) 296 - 9770
F. (202) 296 - 9776
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Comments from the American Thoracic Society
Presented by Mary B. Rice MD
Before the House Committee on Science, Space and Technology on EPA's Proposed Ozone National Ambient Air Quality Standard
March 17, 2015

Mr. Chairman, Ms. Ranking member, my name is Dr. Mary Rice. I am an adult pulmonologist and critical care physician at Beth Israel Deaconess Medical Center and Harvard Medical School in Boston, and also a member of the Health Policy Committee of the American Thoracic Society. When I am not caring for patients, I am engaged in research on the respiratory health effects of ambient pollution exposure in children and adults. On behalf of the American Thoracic Society I want to thank the Committee for the opportunity to testify regarding the Ozone National Ambient Air Quality Standard proposed by the Environmental Protection Agency (EPA). The American Thoracic Society is a medical professional organization with over 15,000 professionals and patients who are dedicated to the prevention, detection, treatment and cure of respiratory disease, critical care illnesses and sleep-disordered breathing. We pursue our mission through research, clinical care, education and advocacy.

It has been known for a long time that ozone (O_3) is a potent oxidant that irritates and damages the airways and lungs. The American Thoracic Society strongly supports EPA's proposal to strengthen the National Ambient Air Quality Standard for ozone. If anything, we are disappointed EPA did not go further is recommending a stronger standard of 60 ppb.

For several years, the ATS has encouraged the EPA to issue a more protective ozone standard. When the standard was reviewed in 2007 under the Bush Administration, we recommended a health-based, 8-hour standard of 60 ppb based on the available evidence at that time[1]. When the Obama Administration first reconsidered this standard in 2010, we again urged 60 ppb[2]. While the recommended standard endorsed by the physician community has not changed during this time, the scientific evidence supporting this recommendation has significantly strengthened. The evidence available seven years ago justifying this recommendation has been supplemented by an even greater understanding of the health effects of ozone exposure, including greater exacerbation of respiratory disease in infants and children, worse lung function in healthy adults and those with lung disease, hospitalization for asthma and chronic obstructive lung disease, and increased mortality in adults. There is clear, consistent, and conclusive evidence that we believe should compel EPA to establish an ozone standard no higher than 60 ppb[3].

Ozone exposures in the range of 60 ppb to 70 ppb have adverse physiologic effects across the entire age spectrum—from newborn infants to the elderly. While there is also some evidence of health effects of ozone exposure below 60 ppb, the strongest evidence supports the conclusion that serious adverse health effects occur across all ages at levels above 60 ppb.

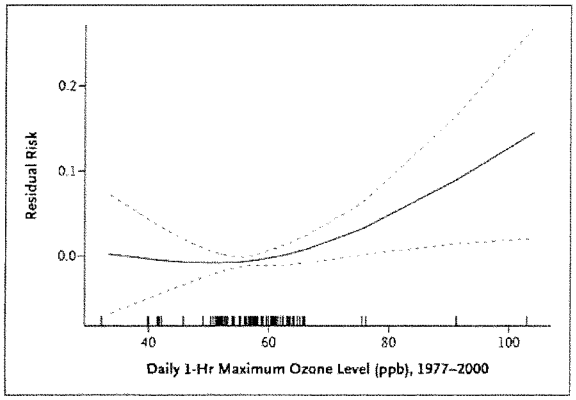
Highlights of this new body of evidence include several lines of evidence demonstrating dose-response relationships between ozone exposure above 60 ppb and childhood asthma hospital admissions and emergency room visits[4-7] and a new study of emergency department visits by preschool children in Atlanta, which found that each 30 ppb increase in the three-day average of ozone was associated with an 8% higher risk of pneumonia[8].

Today, ozone pollution – at levels permissible under the current standard – makes children sick. EPA has the authority and obligation to set a standard that protects children from the adverse health effects of ozone exposure.

But it's not just children -- adults are also harmed by ozone exposure. Research has shown that for each incremental rise in ozone exposure, severe asthma exacerbations, emergency room visits, and hospitalizations for asthma increase for adults[7,9,10]. Similar associations have been found for adult admissions for chronic obstructive pulmonary disease[11,12] and pneumonia[12]. In my own work with colleagues at the Harvard School of Public Health and the Framingham Heart Study, we examined lung function in more than 3,000 healthy adults and found that lung function was substantially lower (by 55 mL) when ambient ozone ranged from 60 to 75 ppb compared to days with levels under 60 ppb[13]. This analysis did not even include any days with levels above our current standard of 75 ppb. Six epidemiological studies in the U.S. and Canada provide further real-world evidence that a standard of either 70 ppb or 65 ppb fails to provide adequate protection. These studies (Bell et al., 2006; Cakmak et al., 2006; Dales et al., 2006; Katsouyanni et al., 2009, Mar and Koenig, 2009; Stieb et al, 2009)[14-19] identified positive associations between ozone exposure and premature death, increased hospital admissions and emergency department visits primarily for respiratory condition as well as cardiac conditions. Controlled human exposure studies have re-affirmed lung function decrements in healthy adults after exposure to 60 ppb to 70 ppb of ozone[20,21]. Numerous animal toxicology studies have demonstrated damage to the lung tissue after ozone exposure, including evidence of lung damage at levels in the 60 to 70 ppb range[22,23].

Perhaps of greatest concern, there is now stronger evidence of increased mortality in association with higher ozone levels[24-26], particularly among the elderly and those with chronic disease[27,28]. These large, multi-city studies found strong and consistent associations with increased risk of premature death, particularly in the warmer months when ozone levels are higher. The figure below, published in a paper in the *New England Journal of Medicine* in 2009, demonstrates the dose-response relationship between ozone levels and death from respiratory causes[29]. There is a linear relationship between ozone concentration and risk of respiratory death above levels of 60 ppb:

Exposure–Response Curve for the Relation between Exposure to Ozone and the Risk of Death from Respiratory Causes



A study published by investigators at the Johns Hopkins School of Public Health estimated the annual numbers of ozone-related premature deaths that could be avoided with full attainment of an ozone standard of 75 ppb, 70 ppb and 60 ppb[30]. If all non-attainment areas in 2005 to 2007 were instead in full compliance with the current 75 ppb standard, an estimated 1500 to 2500 premature deaths would be avoided each year. This increases to 2500 to 4100 premature deaths at 70 ppb, and 5200 to 8000 premature deaths at an attained ozone standard of 60 ppb. This study also estimated that 10 million cases of acute respiratory symptoms and 3.5 million lost school days would be avoided nationally if we attained a standard of 60 ppb of ozone.

In sum, there is abundant and consistent scientific evidence demonstrating that ozone pollution – at levels permitted by the current standard – is damaging to the human lungs and contributes to illness and death. Ozone is particularly harmful to certain people, including babies, children and adults with asthma, people with chronic obstructive pulmonary disease, and the elderly. The EPA and the Administration both have the authority and the obligation to establish a more protective ozone standard. The American Thoracic Society strongly urges EPA and the Administration to finalize a more protective ozone standard of 60 ppb.

I would be happy to answer any questions.

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Mary B. Rice, MD
Professional Biography

Dr. Rice has a longstanding interest in environmental exposures and respiratory health. She graduated from Harvard College in 1999 with a degree in environmental science and public policy. After working in New York City as a consultant and completing premedical studies, she spent a year pursuing research and public policy analysis at the Columbia University Center for Children's Environmental Health, where she studied air pollution, genetic susceptibility, and pulmonary outcomes in a birth cohort of children in New York City. As a medical student at Harvard Medical School, she joined Students for Environmental Awareness in Medicine, a student-run nonprofit. She led the organization as a second year student and organized a conference on health and the environment in Washington DC, and met with senators and staff about air pollution and health. She also developed a small community-based participatory research project in collaboration with Tufts and Boston University to study the prevalence of asthma and environmental triggers in the low-income community of Dorchester. As a resident, she worked with Dr. David Christiani of Massachusetts General Hospital, investigating the effects of particulate matter exposure on lipid levels in a cohort of welders, which resulted in a first author publication in the *Journal of Occupational and Environmental Medicine*. She then pursued clinical and research training in pulmonary and critical care medicine at Harvard Medical School, with the goal of understanding how respiratory health is affected by environmental exposures.

As a pulmonary fellow, she selected as a primary research mentor Dr. Murray Mittleman, a physician epidemiologist at Beth Israel Deaconess Medical Center and the Harvard School of Public Health with expertise in epidemiologic methods and environmental epidemiology. Under Dr. Mittleman's mentorship, Dr. Rice completed coursework for a Master's Degree in Public Health at the Harvard School of Public Health (graduation March 2015). She successfully obtained an F32 NRSA career development award from the National Institute for Environmental Health Sciences to study air pollution exposure and lung function in the Framingham Heart Study. This research has resulted in important scientific findings. In particular, Dr. Rice and colleagues found that previous-day exposure to criteria air pollutants, within current EPA standards, was associated with lower lung function in the Framingham Heart Study. Secondly, Rice and colleagues found that long-term estimates of traffic and particulate air pollution exposure are associated with accelerated lung function decline, of a magnitude similar to the effect of former smoking. These findings resulted in two first author manuscripts in the *American Journal of Respiratory and Critical Care Medicine* and a first place award in the 9th Annual Respiratory Disease Young Investigators' Forum.

Dr. Rice is a member of the faculty of Harvard Medical School and Beth Israel Deaconess Medical Center and was promoted to the position of Instructor in Medicine in July, 2014. She is board certified in internal medicine, pulmonary disease and critical care medicine. She spends 75% of her effort investigating associations between measures of long-term exposure to ambient air pollution and pulmonary structural abnormalities in generally healthy adults and has proposed new research to study associations between measures of daily pollution exposure and lung function and respiratory symptoms in adults with chronic obstructive pulmonary disease (COPD). She serves on the faculty advisory committee of the Harvard Center for Human Health and the Global Environment and on the Environmental Health Policy Committee of the American Thoracic Society. As a clinician, Dr. Rice cares for ambulatory patients in her general pulmonary clinic and for hospitalized patients on the wards and in the intensive care unit of Beth Israel Deaconess Medical Center.

Chairman SMITH. Thank you, Dr. Rice.

Dr. Lefohn?

TESTIMONY OF DR. ALLEN S. LEFOHN, PRESIDENT, A.S.L. & ASSOCIATES

Dr. LEFOHN. Thank you. Thank you very much for inviting me here today. It is a long way from Last Chance Gulch in Helena, Montana.

My name is Allen Lefohn. As the Chairman has indicated, I have a Ph.D. from UC Berkeley. I perform research for environmental organizations, federal and tribal governments, the U.S. Congress, the White House, the United Nations, and industrial clients. I have published over 125 peer reviewed publications, and serve as an executive editor of "Atmospheric Environment." Today I am speaking on my own behalf.

Background ozone plays an important role in affecting the selection of the level of the human health standard. In my testimony I will discuss how current levels of background ozone make up a substantial portion of the observed ozone across the United States. As emissions are reduced, EPA has estimated cumulative mortality and morbidity health risks that will be heavily impacted by background ozone. EPA's margin of safety is influence by background ozone.

Why is background important in the standard setting process? Background ozone is continually contributing to observed concentrations that influence risk estimates across the entire United States. Background also contributes to exceedances of the standard and attainability.

What happens to ozone concentrations when emissions are reduced to attain the ozone standard? Efforts to control ozone will not only reduce peak ozone concentrations, but will cause the low level concentrations to shift upward. The result is that mid-range values, 25 to 55 parts per billion, will dominate the distribution of concentrations. EPA's mortality and morbidity risk estimates are dominated by the mid-range concentrations. Background makes up a large percentage of these concentrations.

What is EPA's conclusion about the relative importance of background ozone? EPA, and our international research team's findings, agree that background ozone makes up a relatively large percentage, 70 to greater than 80 percent, of the observed ozone within the intermountain western U.S., and along the northern and southern U.S. border. The orange and red circles in this slide illustrate where the large percentages occur. For many low elevation sites across the U.S., the contribution of background ranges from 50 percent to greater than 80 percent, as illustrated by the green, yellow, orange, and red colored circles.

What is EPA's opinion on the role that background plays in attaining alternative ozone standards across the U.S.? EPA agrees that there is no question that as the levels of potential alternative standards are lowered, background will represent increasingly larger percentages of total ozone, and may subsequently complicate efforts to attain these potential standards.

How much does background contribute currently within specific concentration ranges? Yellowstone National Park in Wyoming is dominated by background ozone throughout the year, with minor anthropogenic contributions. In this slide, the relative contribution of background, noted by blue, to anthropogenic, noted by red, within each concentration level shows that background contributes greater than 80 percent, including the mid-range, which is an important range that I have indicated influences EPA's human health risk estimates. In the next slide, for Denver, the contribution of background within the mid-range concentrations is approximately 75 to 80 percent. For Los Angeles, a site heavily influence by anthropogenic emissions, background contributes 60 to 80 percent in the mid-range.

How does background influence the EPA's human health risk estimates? As emissions are reduced, background influenced concentrations in the mid-range dominate the cumulative mortality health risks. In some cases, 90 percent or more of the accumulated risk is associated with mid-range for cities across the U.S. The different colors represent the different standard scenarios. Results shown here are similar for all 12 cities in the epidemiological risk analysis. The Administrator has placed greater weight on controlled human exposure studies, rather than on epidemiological results.

As emissions are reduced, we investigated the degree to which EPA's lung function risk estimates are affected by the background influenced concentrations in mid-range for Los Angeles, Denver, Houston, Philadelphia, and Boston. We found that three, Los Angeles, Denver, and Houston, of the five cities, a large percentage of the cumulative frequency of responses is affected by background influence mid-range.

In conclusion, background will be a regional attainment problem in the west and the intermountain west. There is no doubt about that. The EPA Administrator will use the background influenced EPA mortality, morbidity, and lung function risk estimates to provide a margin of safety when setting the ozone standard. Background cannot be ignored, and plays an important role in informing the administrator on the final selection of the level of the ozone standard.

Thank you very much.

[The prepared statement of Dr. Lefohn follows:]

Testimony by Allen S. Lefohn, Ph.D.
to
The House Committee on Science, Space, and Technology

March 17, 2015

My name is Allen Lefohn. I have a Ph.D. from UC Berkeley. I have performed research for environmental organizations, federal and tribal governments, the U.S. Congress, the White House, the United Nations, and industrial clients. I have published over 125 peer-reviewed publications and served as an Executive Editor of *Atmospheric Environment*.

Today, I am speaking on my own behalf.

Background ozone plays an important role in affecting the selection of the level of the human health ozone standard.

In my testimony I will discuss:

- Current levels of background ozone make up a substantial portion of the observed ozone across the U.S.
- As emissions are reduced, EPA's estimated cumulative mortality and morbidity health risks will be heavily influenced by background ozone.
- EPA's margin of safety is influenced by background ozone.

Why is background important in the standard-setting process?

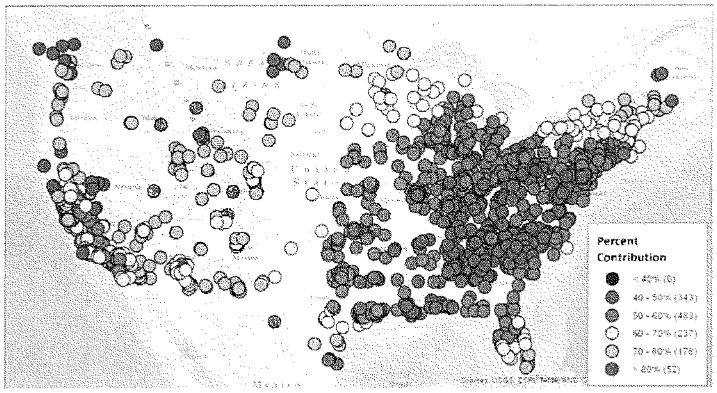
Background ozone is continually contributing to observed concentrations that influence risk estimates across the U.S. Background also contributes to exceedances of the standard and attainability.

What happens to ozone concentrations when emissions are reduced to attain the ozone standard?

Efforts to control ozone will not only reduce peak ozone concentrations, but will cause the low-level concentrations to shift upward. The result is that mid range values (i.e., 25 – 55 ppb) will dominate the distribution of concentrations. EPA's mortality and morbidity risk estimates are dominated by mid-range concentrations range (EPA, 2014b, c). **Background makes up a large percentage of these mid-range values (Lefohn et al., 2014).**

What is EPA's conclusion about the relative importance of background ozone?

EPA's and our findings (Lefohn et al., 2014) agree that background ozone makes up a relatively large percentage (e.g., 70 to greater than 80%) of the observed ozone within the intermountain western U.S. and along the northern and southern U.S. border. The orange and red circles in Slide 3 illustrate where the large percentages occur. For many low-elevation sites across the U.S., the contribution of background ranges from 50% to greater than 80% as illustrated by the green-, yellow-, orange- and red-colored circles (EPA, 2014a).



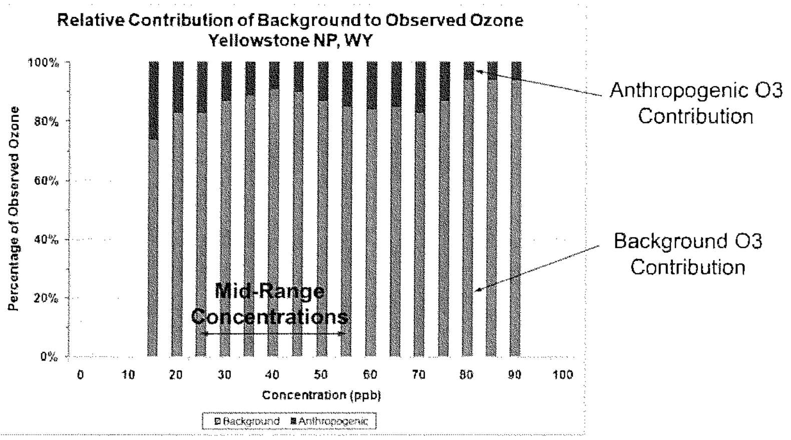
Slide 3. Map of site-specific ratios of apportionment-based U.S. background to seasonal mean ozone (April-October) based on 2007 CAMx source apportionment modeling. (Source: page 2-22 of EPA's Policy Assessment Document (EPA, 2014a)).

What is EPA's opinion on the role that background plays in attaining alternative ozone standards across the U.S.?

EPA (Federal Register, 2014 page 75383) agrees that there is no question that as the levels of potential alternative standards are lowered, background will represent increasingly larger percentages of total ozone and may subsequently complicate efforts to attain these potential standards.

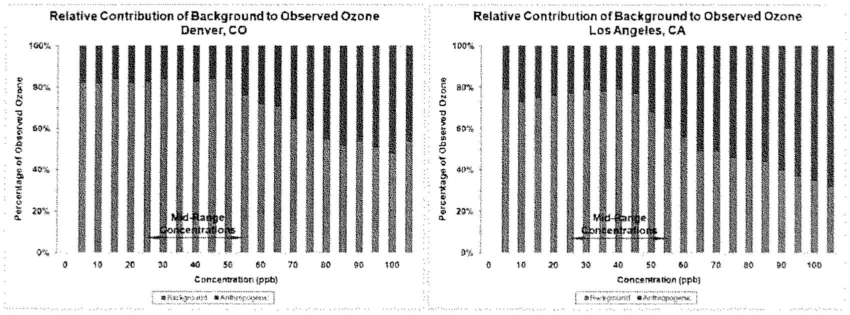
How much does background contribute currently within specific concentration ranges?

Yellowstone National Park in Wyoming is dominated by background ozone throughout the year with minor anthropogenic contributions (Lefohn et al., 2014). In Slide 4, the relative comparison of background (noted by blue) to anthropogenic (noted by red) within each concentration level shows that background contributes greater than 80%, including the mid-range (20-25 ppb), which is an important range that influences EPA's human health risk estimates.



Slide 4. Average relative contributions of current hourly background (blue) and anthropogenic ozone (red) for Yellowstone NP (WY). (Source: Lefohn et al., 2014).

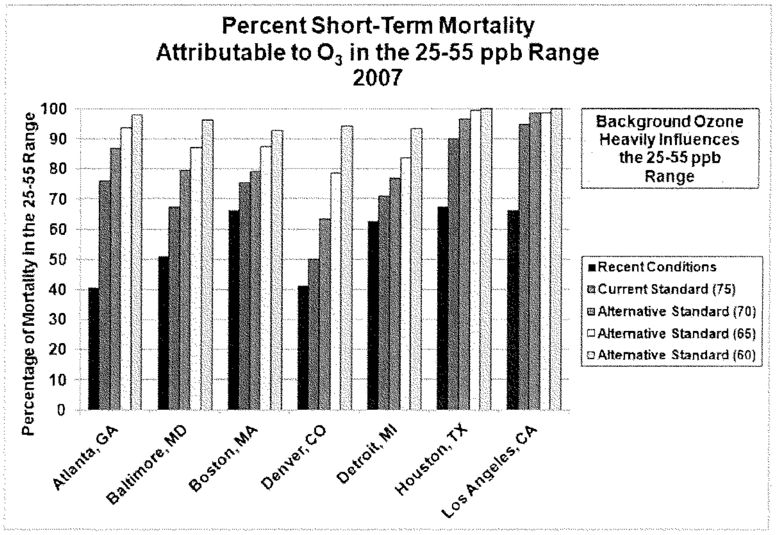
In Slide 5, for Denver, the contribution of background within the mid-range concentrations is approximately 75 to 80%. For Los Angeles, a site heavily influenced by anthropogenic emissions, background contributes 60-80% in the mid-range.



Slide 5. Average relative contributions of current hourly background (blue) and anthropogenic ozone (red) for Denver (CO) and Los Angeles (CA). (Source: Lefohn et al., 2014).

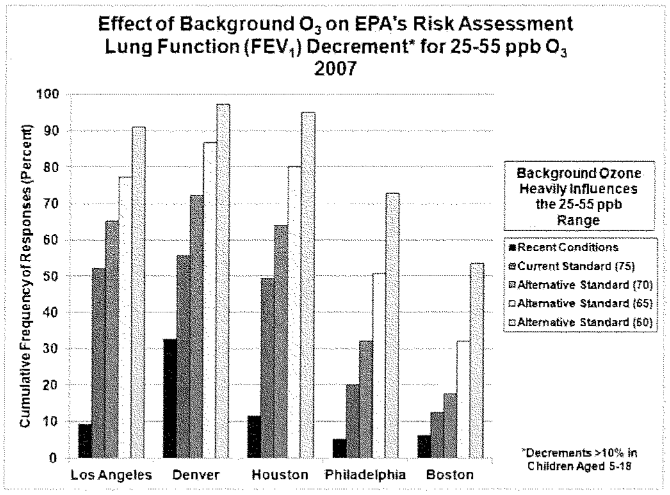
How does background influence the EPA's human health risk estimates?

As emissions are reduced, background-influenced concentrations in the mid-range dominate the cumulative mortality health risk estimates (Slide 6). In some cases, 90% or more of the accumulated risk is associated with the mid-range for cities across the U.S. The different colors represent the different standard scenarios. Results shown here are similar for all 12 cities used in the epidemiological risk analyses.



Slide 6. Percent short-term ozone-attributable mortality in the 25-55 ppb range for various exposure conditions for 2007 for 7 of 12 cities. (Source: Data from Fig. 7-B1 on page 7-B3 of EPA, 2014c).

The Administrator has placed greater weight on controlled human exposure studies rather than on the epidemiological results (Federal Register, 2014 page 75288). As emissions are reduced, we investigated the degree to which EPA's lung function risk estimates are affected by the background-influenced concentrations in the mid-range for Los Angeles, Denver, Houston, Philadelphia, and Boston. We found that for 3 (i.e., Los Angeles, Denver, and Houston) of the 5 cities, a large percentage of the cumulative frequency of responses is affected by background-influenced mid-range concentrations (Slide 7).



Slide 7. The percentage of the cumulative frequency of responses in children aged 5-18 associated with the 25-55 ppb range for the Los Angeles, Denver, Houston, Philadelphia, and Boston urban study areas using EPA's APEX model.

Background will be a regional attainment problem in the West and Intermountain West. The EPA Administrator will use the background-influenced EPA mortality/morbidity and lung-function risk estimates to provide a margin of safety when setting the ozone standard. Background cannot be ignored and plays an important role in informing the Administrator on the final selection of the level of the ozone standard.

Thank you

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Biographic Sketch of Dr. Allen S. Lefohn

Allen S. Lefohn is President and Founder of A.S.L. & Associates in Helena, Montana, a firm he founded in 1981. He received his Bachelor's degree from UCLA in 1966 and a Ph.D. in physical chemistry from the University of California at Berkeley in 1969. Dr. Lefohn has published over 125 peer-reviewed publications, edited four books, presented oral papers, and participated in a number of panel presentations. During a career spanning almost 50 years, besides focusing his research on understanding the relative importance of background ozone, Dr. Lefohn's has developed exposure-response relationships and indices that describe the effects of ozone on vegetation and human health, as well as the analysis of air quality data in biologically relevant forms for effects assessment purposes. Dr. Lefohn was the lead consultant scientist for the EPA in authoring the air quality characterization chapter and the vegetation exposure-response section for the Ozone Criteria Document in 1996 and contributed to the Ozone Criteria Documents in 1985 and 2006. For the period 1989 – 1999, Dr. Lefohn served as an Executive Editor of the internationally recognized technical journal *Atmospheric Environment* and is an Emeritus Editor of the Journal. Dr. Lefohn is a co-guest editor with Dr. Owen Cooper of the NOAA Earth System Research Laboratory in Boulder, Colorado for the upcoming *Atmospheric Environment* special issue: Observations and source attribution of ozone in rural regions of the Western United States. In December 2014, Dr. Lefohn was invited to serve on the Steering Committee for the international research program, Tropospheric Ozone Assessment Report (TOAR): Global metrics for climate change, human health and crop/ecosystem research. The project will provide the research community with an up-to-date scientific assessment of tropospheric ozone's global distribution and trends from the surface to the tropopause. Besides focusing his professional time on scientific research, Dr. Lefohn is a professional photographer who captures the magical artistic moments associated with the performing arts (i.e., symphony and ballet). He is currently serving as the artistic photographer for the Helena Symphony. He has held the position since 2003. He is currently an Adjunct Professor of Environmental Engineering at Montana Tech in Butte, Montana.

Chairman SMITH. Thank you, Dr. Lefohn.

And Mr. Heaston?

TESTIMONY OF MR. ELDON HEASTON, EXECUTIVE DIRECTOR, MOJAVE DESERT AQMD, ANTELOPE VALLEY AQMD

Mr. HEASTON. Good morning. I am Eldon Heaston, the Executive Director, Air Pollution Control Officer for the Mojave Desert Air Quality Management District, and also for the Antelope Valley Air Quality Management District. I am here as one of the people who will have to implement the Clean Air Act provisions that will be triggered if the new ozone NAAQS is changed. My two districts are located in inland Southern California, adjacent to, and directly downwind from the Greater Los Angeles area. Together my districts cover more than 21,000 square miles in three different counties. Area-wise, my districts are as big as some states.

Antelope and Mojave are overwhelmingly impacted by transported NOX and VOC, primarily from the Los Angeles basin. It is this simple fact that drives most of my concerns with the proposed ozone standard. The ozone precursor inventory for Antelope Valley and Mojave is approximately 192 tons a day. This is in comparison to roughly 1,000 or 1,100 tons per day in the South Coast Air District, our biggest upwind contributor.

So what does this mean? Well, to be blunt, we could shut everything down in the desert, no industry, no transportation, no housing, no nothing, and we would still have exceedances of the current 2008 standard. In fact, my district will never attain the current standard unless and until our upwind neighbors manage to do so. Our upwind neighbors, South Coast and the San Joaquin Valley, are struggling to find sufficient emission reductions to attain even the current ozone standard. Their plans rely heavily on technology forcing measures, and the so-called black box reductions which may not, if ever, be technologically or economically viable. I fear that if the proposed ozone standards are enacted that the entire southern half of California will need to be an all-electric zone to meet the requirements of the Clean Air Act.

I am also concerned that some of the lower standard proposals are getting seriously close to the ambient background. So, I mean, how do you improve air quality better than ambient? Another problem with this is that the closer the standard gets to background levels, the greater the impact will be of long range transported pollutants from other countries and ships at sea. These are sources over which you and I have no control.

In general, the Clean Air Act has done a pretty good job of controlling stationary source emissions. How can we tell? Well, the emissions inventory has shifted from being mostly stationary or industrial in nature to be more mobile, and area source driven. In Mojave and Antelope, mobiles run 61 to 66 percent of our ozone precursors. In South Coast and San Joaquin, it is 85 and 80 percent respectively. To achieve attainment, we are going to need to do more about emissions from planes, trains, ships, and automobiles. Under the Act, a change in the NAAQS is not going to mandate mobile controls to the same extent as required for stationary source emissions.

Even if you do control the mobile sources themselves more effectively, there still remains the problem that, in my district, over 140,000 residents commute over 60 miles one way to jobs into the L.A. basin. Inherently the more miles a vehicle travels, the more pollution on a per vehicle basis. This means that one of the best, most efficient mobile source control for my district is to move the jobs closer to the people. Unfortunately, this will be more difficult with a lower standard.

The Clean Air Act amendments have been in existence for over 20 years now. Given where we started, we have come a long way, and we are making progress. Antelope and Mojave have managed to attain the old one hour standard. We are only now beginning to implement the current plans and rules under the 2008 8-hour standard. Unfortunately, the proposed new standards will change the playing field again. I fear that the net result, at least in our district, will be to confuse the public into thinking that air pollution is becoming worse, when, actually, it is getting better. I also am concerned that it is going to make it extremely difficult for industry to comply so soon after upgrading to comply with the current standards. Despite the fact that it gives me job security, it seems we are chasing an ever-shifting goal.

One of the things that I think we can all agree upon is that the intent of the NAAQS is to protect public health. It is our duty, as responsible government officials, to do this in a cost-efficient manner by getting the most health protection for each dollar that we spend on pollution control. A good portion of our district is open desert, with very little population per square mile. Part of that area is currently unclassified. However, if the entire district becomes non-attainment, the cost of compliance for additional industrial sources in the outlying areas will increase substantially, hurting even more small business.

As company compliance spending increases, they generally cut costs elsewhere, often in personnel. As you are no doubt aware, economic opportunity and economic status also have a direct correlation with public health. I fear that the proposed new NAAQS might improve air quality at the expense of increasing the health burden caused by the lack of economic opportunity.

I appreciate very much the opportunity to come and testify here today, and if there is any additional information I can provide, I will be glad to answer your questions.

[The prepared statement of Mr. Heaston follows:]

Mojave Desert Air Quality Management District
14306 Park Avenue, Victorville, CA 92392-2310
760.245.1661 • fax 760.245.2699
Visit our web site: http://www.mdaqmd.ca.gov
Eldon Heaston, Executive Director

Testimony of Eldon Heaston on behalf of the Mojave Desert Air Quality Management District and the Antelope Valley Air Quality Management District before the Congress of the United States, House Committee on Science, Space and Technology for a hearing entitled *Reality Check: The impact and Achievability of EPA's Proposed Ozone Standards.*

March 17, 2015
10:00 A.M.
Room 2318 Rayburn House Office Building
Washington, DC

Good Morning. I am Eldon Heaston the Executive Director/Air Pollution Control Officer for the Mojave Desert Air Quality Management District (MDAQMD or Mojave District) and the Antelope Valley Air Quality Management District (AVAQMD or Antelope District). I'm here today as a regulator and one of the people who will be required to develop and implement the plans and regulations which would be necessary if there is a change to the National Ambient Air Quality Standards for Ozone. I would like to thank the committee which has given me this opportunity to testify.

My two Districts are located in inland Southern California, adjacent to and directly downwind from the greater Los Angeles area. The MDAQMD covers more than 20,180 square miles of desert San Bernardino County and the Palo Verde Valley region of Riverside County with an approximate population of 552 thousand people. The jurisdiction of the AVAQMD includes the desert portion of Los Angeles County with approximately 1,300 square miles and an estimated population of 460 thousand.

Due to the prevailing wind direction and topography these two air districts are overwhelmingly impacted by transported Ozone and its precursors, Oxides of Nitrogen (NOx) and Volatile Organic Compounds (VOC[1]), from both the greater Los Angeles area and the San Joaquin Valley. It is this simple fact that drives most of my concerns with not only the proposed Ozone standard but also the most recent 2008 .075 ppm 8 hour standard. Currently the entire AVAQMD is designated nonattainment for Ozone and the MDAQMD is nonattainment for the Victor Valley area. The ozone precursor inventory for the Antelope Valley and Mojave Desert

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[1] In the California emissions inventory VOC is referred to as Reactive Organic Gasses or ROG.

Districts is approximately 192 tons per day (tpd) combined[2]. This is in comparison to roughly 1078.93 in the South Coast Air Quality Management District (SCAQMD or South Coast District)[3] which covers the greater Los Angeles Area or 692.93 in the San Joaquin Valley Unified Air Pollution Control District (SJVUAPD or San Joaquin District)[4]. Unfortunately this means that even if there were absolutely no air pollution emissions in either the Antelope or the Mojave District these areas would still exceed the current 2008 standard. The net result of this natural situation is that the Antelope and Mojave Districts can NEVER attain even the current 2008 Ozone standard unless and until our upwind neighbors manage to do so.

Both the South Coast and San Joaquin districts are designated nonattainment for Ozone and classified as extreme, the worst classification available. They are struggling to find sufficient emissions reductions to attain the current Ozone standard. Their plans rely heavily on technology forcing measures and so called "black box" reductions which may not, if ever, be technologically or economically viable. However without postulating such reductions neither they, nor in turn my districts, can ever achieve attainment. I fear that if the proposed Ozone standards are enacted, especially at the lower end of the ranges contemplated by EPA that the entire Southern California region will need to be an all-electric zone to meet the requirements contained in the Clean Air Act.

I am also concerned that some of the lower standard proposals, namely the .060 to .065 ppm ranges are getting seriously close to the ambient background levels of Ozone. The closer the standard gets to background levels the greater the impact will be of long range transported pollution from other countries and ships at sea. These are sources over which local air districts have no control. Even you, as the Congress have little or no influence upon other countries or foreign flagged vessels. However if the standards are lowered, reductions in such emissions will be necessary to achieve attainment.

As you are all well aware, one general assumption underlying the Clean Air Act was that a major component of the air pollution problems was derived stationary sources. Now over the years since its enactment collectively we've done a pretty good job of controlling stationary source emissions. This is reflected in the fact that our emissions inventory has shifted from being mostly stationary in nature to being mostly mobile and area-wide[5]. In the Mojave District our pollution inventory is now 61% mobile and area-wide sources for ozone precursors. Likewise, in the Antelope District it is 66%. In the South Coast and the San Joaquin Districts the percentages are 85% and 80 % respectively. Therefore, in order to achieve attainment of the current standards as well as any newly proposed standards these going to need to vigorously addressed. Of course these types of sources are primarily within the preview of the Federal Government and will need to be addressed at the national level.

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[2] MDAQMD 2012 Inventory for Ozone precursors = 116.61 tpd NOx and 38.58 tpd VOC. AVAQMD 2012 Inventory for Ozone precursors = 18.56 tpd NOx and 16.27 tpd VOC. See http://www.arb.ca.gov/ei/maps/statemap/dismap.htm.

[3] SCAQMD 2012 Inventory for Ozone precursors = 584.25 tpd NOx and 494.73 tpd VOC.

[4] SJVUAPCD 2012 Inventory for Ozone precursors = 321.27 NOx and 371.66 VOC.

[5] Sources of pollution where the emissions are spread over a wide area, such as consumer products, fireplaces, road dust and farming operations. Area-wide sources do not include mobile sources or stationary sources. See: http://www.arb.ca.gov/html/gloss.htm

California has been leading the way in attempts to regulate mobile sources especially diesel. However we still have a problem in that the sheer number of vehicles and vehicle miles traveled contribute substantially to the Ozone problem. In my districts, for example, a large portion of the population commutes over 60 plus miles one-way to work to jobs located within the Los Angeles basin. Thus one of the best mobile source control measures available in the Antelope and Mojave Districts is to move the jobs and the people doing them closer together. The more stringent controls required by a proposed new standard will make it inherently more difficult to site new industry or move existing stationary sources to lessen vehicle miles traveled and the pollution created by those vehicles.

Another problem arising from the Clean Air Act itself is the premise that all nonattainment areas are created equal. It assumes that a high concentration of a criteria pollutant is generated by sources in direct proximity to where the measurement was taken. This is not always the case. Once again I must stress that transport, both regional and international, is not addressed very well in the act or in its implementation. For example, there have been several proposals over the years by EPA to not allow a particular area to rely on upwind reductions in showing progress under the Act. In a transport impacted area such as my districts the net result would be to require stringent and costly controls in an area with little or no overall air quality benefit. The proposed new Ozone standards will, once again, not again address this fundamental underlying issue.

The Clean Air Act has, overall, been quite effective in reducing air pollution. However, we have just begun to really reap the benefits of regulations, plans and control equipment put into place as a result of the 1 hour Ozone standard. The plans and rules needed for the current 8 hour standard are just now beginning to be implemented. Industrial sources are just now starting to install new controls to comply with these new rules. It will take a few years at the minimum to determine the full extent to which these regulations are effective. Unfortunately, the proposed new standards will change the playing field again. I fear the net result, at least in the Antelope and Mojave Districts will be to confuse the public into thinking that air pollution is becoming worse. I also am concerned that it will make it extremely difficult for industry to comply with new provisions so soon after upgrading to comply with the current standards.

One of the things that I think we can all agree upon is that it is the intent of the NAAQS to protect the public health. It is our duty as reasonable governmental officials to do this in a cost efficient manner by getting the most health protection for each dollar spent on pollution control. As I mentioned before most of the population base in the Mojave District is located in and around the cities of the Victor Valley. There are several outlying pockets of population namely Barstow, Needles and Blythe but the remainder of the district is open desert with a very low population per square mile. If the entire 20 thousand plus square miles of the Mojave District becomes nonattainment, as I suspect it will be, the cost of compliance for industrial sources in those outlying areas will increase substantially without a corresponding benefit to public health. In fact, I fear that there may be an unintended consequence in that as company compliance spending increases there will be less spending on employment. As you are no doubt aware economic opportunity and economic status often has a direct correlation with public health. I fear the unintended consequence of improve air quality at the expense of increase the health burden caused by the lack of economic opportunity for the residents of my districts.

I appreciate very much the opportunity to come and testify here today. If there is any additional information that I can provide or any questions that you feel I may be able to answer for you I will be happy to do so.

ELDON HEASTON
Executive Director
Mojave Desert Air Quality Management District and
Antelope Valley Air Quality Management District
Victorville and Lancaster, California (Respectively)

Eldon Heaston was appointed Executive Director of the Mojave Desert Air Quality Management District in March 2006. During his twenty-three years with the District, Heaston has worked to build and uphold its reputation as one of the most progressive and accessible air districts in the state.

Prior to his appointment as Executive Director, Heaston served as the Deputy Air Pollution Control Officer for eleven years. In that capacity he managed the day-to-day operations of both air districts, including compliance, regulatory development, engineering, air monitoring and the small business assistance program. Prior to that, he was the Environmental Services Manager, whereby he was responsible for the development and implementation of the District's AB2588 Toxic "Hot Spots" Program, rule development, health risk assessment/modeling, and Federal and State Implementation Plan (SIP) development.

Before joining the District, Heaston spent over eleven years in the aerospace and petrochemical industry where he held various positions in operations, industrial hygiene and environmental management.

Heaston recently served six years as a Governor's appointee to the state's Inspection and Maintenance Review Committee, which evaluated the effectiveness of California's Smog Check Program and recommended program improvements.

Heaston is a founding member of the Mojave Desert Chapter of the Air & Waste Management Association, and a Past Chair of the West Coast Section of A&WMA. Heaston has also served as an adjunct faculty member for California State University, San Bernardino. Mr. Heaston holds a B.S. Health Science.

Chairman SMITH. Thank you, Mr. Heaston, and I will recognize myself for questions. And, Mr. Alford, let me direct my first question to you.

And that is, you touched upon this in your testimony, but who would be hit the hardest by this proposed rule?

Mr. ALFORD. Those with fewer resources. People in poverty, people unemployed, urban inner city areas, rural areas. You know, people who don't have access to jobs, or their job may be tentative, or tenuous, and anything like this occurring eliminates the possibility. Jobs are the linchpin to quality of life, and to health.

Chairman SMITH. Thank you, Mr. Alford, appreciate that.

Mr. Keating, why would small businesses in non-attainment areas have a particularly difficult time complying with the proposed rule?

Mr. KEATING. Yeah, think about it from a small business perspective. The costs, you know, you have seen markets develop in some of these areas for these kind of trade-offs, and they are enormously expensive. The regulatory burdens, the paperwork, all of those things, when you factor that in for a small business owner, essentially is a stop sign. It is not even a yield sign. So, again, when you look at the cost of regulations, when you see how much more costly regulations are for small businesses versus large businesses, you look at the—on the environmental front, where, again, the difference is even greater, this is a clear negative for starting up and expanding your business.

Chairman SMITH. Okay. Thank you, Mr. Keating.

And, Dr. Lefohn, does this proposed rule rely primarily upon just one study, and if so, what are the limitations of that study?

Dr. LEFOHN. Looking at what the Administrator has placed into the proposal, it is clear to me that the Schlagele, et al experiment from 2009 is the key experiment. What Ed Schlagele did—and I designed the exposures that he used, along with Dr. Milan Hazucha from UNC, we designed the exposures—what Ed Schlagele did was expose college students to various levels of ozone. And in that experiment, he found a statistically significant effect at what I had designed for a 70 part per billion exposure, variable exposure, meaning raising and lowering the concentrations over 6.6 hours. He attained 72 parts per billion over the time period. The net result is the Administrator has clearly shown and stated within the proposal that 72 parts per billion is the line that she is going to use.

She then will superimpose on top of that line a margin of safety. That margin of safety, she has said, she will feel comfortable in getting down to 70 parts per billion, or to 65 parts per billion. But is the—but it is the Schlagel, et al experiment that appears to be driving the——

Chairman SMITH. Right.

Dr. LEFOHN. —proposal.

Chairman SMITH. And isn't it true that this experiment on which the rule primarily rests only had 31 participants, or is that——

Dr. LEFOHN. That is correct. There were 31, but a lot of the experiments are—I think in this case there were supposed to be 32, but there were——

Chairman SMITH. Okay.

Dr. LEFOHN. —but there were 31——

Chairman SMITH. Okay.

Dr. LEFOHN. —that were used. But the bottom line is this, is that those experiments are very expensive and lengthy to do.

The experiment itself, I think that the debate concerning the level of the standard needs to focus on the strengths and weaknesses of Ed Schlagele's experiment, and also on the margin of safety to——

Chairman SMITH. Okay.

Dr. LEFOHN. —some of the quantification that will go into that.

Chairman SMITH. Okay. Thank you, Dr. Lefohn.

And, Mr. Heaston, many areas of California are not in attainment. Does the technology even exist to allow these areas to comply with the proposed rule?

Mr. HEASTON. Right now there is still substantial—what we call black boxes—I referenced those in my testimony, that those technologies haven't been developed, and——

Chairman SMITH. Right.

Mr. HEASTON. —they were heavily relied on in order to meet their attainment——

Chairman SMITH. So as a practical matter, how can people comply with the rule if the technologies don't exist? Or is that a question——

Mr. HEASTON. We have—as an air district, you have to come up with—means. You have to either go to other categories, or reduce in other areas. If you can't get it one particular area, you would have to move over to another category in order to do it. So someone else would have to—some other area of emissions in your district would have to be lowered to make up the difference. Everything has to come out, you know, to attainment.

Chairman SMITH. Okay. Thank you, Mr. Heaston. That concludes my questions, and the gentlewoman from Texas is recognized for hers.

Ms. JOHNSON. Thank you very much, Mr. Chairman. Before I begin my questions, I have a few items I would like to submit for the record. First I have two articles from the Center for Public Integrity, one that provides a clear overview of the problems ozone causes, and the history of intense lobbying that surrounds this issue, including the American Petroleum Institute's efforts to convince America that trees cause as much ozone pollution as cars.

The second article describes how the State of Texas has fought against strict ozone standards in tandem with industry, despite calls from Texans for clean air. Also, since we will likely be discussing the costs associated with the new ozone standard, I have here a study sponsored by the Nature Conservancy and the Dow Chemical Company, which concluded that re-forestation could be a viable, novel approach for abating ground level ozone pollution that complements conventional technology-based controls.

Additionally, I have a letter from the Environmental Defense Fund that highlights the sky is falling claims from industry, and the true cost of inaction. The cost to families, the cost to taxpayers, the cost to hospitals, and it goes on——

Chairman SMITH. Without——

Ms. JOHNSON. —affected by ozone. And finally, I have an article from one of our witnesses, Dr. Rice, which outlines the scientific evidence in support of lower ozone standards. And I ask unanimous consent that these items be included in the record.

Chairman SMITH. Without objection, those four items will be made a part of the record.

[The information appears in Appendix II]

Chairman SMITH. And although the clock has been running, we won't subtract the time you took to read those excerpts from your time for questions, so we will start over again, and give the Ranking Member five minutes for questions.

Ms. JOHNSON. Thank you very much, Mr. Chairman, you are getting better.

In your testimony, Dr. Rice, you state that while the recommended standards of 60 parts per billion endorsed by the physician community has not changed, the scientific evidence supporting the recommendation has significantly strengthened. You reviewed some of this new scientific evidence in your testimony, but can you please go over it one more time? How has the body of scientific evidence changed over the last seven years, and is there a particular set of studies or results that have significantly advanced our understanding of the impacts of ozone on public health?

Dr. RICE. Certainly, Congresswoman, thank you. So nearly ten years ago, in 2006, the American Thoracic Society recommended a 60 part per billion standard, as you discussed, and that was based on the evidence available at that time. And since that time, we have been able to study the effects of ozone, both in the U.S. and in Europe, as ozone levels have continued to decline, thanks to the successes of the Clean Air Act that we have already realized. And that has allowed us to study—to have a larger number of studies where ozone levels are lower, with many studies where ozone levels average in the ranges of 30s, 40s, 50s, and 60s. And I would say, as a scientist, I look for consistency among multiple studies before I begin to conclude that a particular exposure is associated with a particular health effect. And this has really been the case with research on ozone, because there has been remarkable consistency, both from the evidence that was available in 2006, and the additional evidence that has accumulated over the last 8 to 9 years.

You asked whether there are particular sets of studies that I would highlight, and I would say that there are now more sophisticated studies that examine the effects of multiple pollutants, not just one pollutant at a time, to try to disentangle the effects of the different pollutants, because some of them share the same sources. And the studies have generally found that the effect of ozone is independent of other pollutants, that it is not the same health effect as, for example, particulate matter. And there are also now a significantly larger number of studies looking at health effects in children, and particularly respiratory infection in very young children. That evidence has significantly strengthened over the last 8 to nine years. And perhaps a third set of studies I would emphasize is the body of evidence surrounding the association between ozone exposure and mortality. That association is very robust, whether you look here in the United States, you look in Europe, you look in South America. Combining the results of multiple studies, that association is seen over and over again.

Ms. JOHNSON. Thank you. I know that some of your research has focused on the health implications of climate change. It is my understanding that, while EPA projections show that ozone levels will continue to decline, over the next decade especially, if standards such as the one we are discussing today are implement, the research also indicates that temperature changes associated with climate change have the potential to offset improvements in ozone air quality. Can you please comment on this, and the health implications of climate change, especially changes in ozone?

Dr. RICE. Certainly. Ozone is a secondary pollutant, and it is formed as a result of chemical reactions between nitrogen oxides, volatile organic compounds, and those reactions are promoted in the presence of higher temperatures and sunlight. And so one of the major health consequences of high temperature events is also high ozone events, and that is actually what experience has shown, as we have seen a number of heat waves in the last decade. When those heat waves have happened, ozone levels have reached dangerously high levels. And because of that, we have seen higher rates of admissions for respiratory disease, and higher mortality. That has gotten, certainly, a lot of attention in the press during these high temperature events, heat waves.

And when scientists have gone back to try to determine what the causes of those increases in mortality have been, they found that some of the increased death is due to the temperature itself, but some of that higher death is due to the higher ozone levels that accompany the higher temperatures. So that is just all the more reason, with the change in climate, that we need an ozone standard that is protective.

Ms. JOHNSON. Thank you very much. Mr. Chairman, my time has——

Chairman SMITH. Okay. Thank you, Ms. Johnson. The gentleman from Florida, Mr. Posey, is recognized for his questions.

Mr. POSEY. Thank you, Mr. Chairman. Everybody wants clean air and clean water. And I really love the quote of Mr. Alford, with the National Black Chamber of Commerce and its members, when he said they value and support clean air, clean water, and environmental quality. We also value and support economic growth, job creation, and prosperity for our individual members, and this country as a whole. These are not mutually exclusive goals. We hope EPA will hear the concerns of our organization and others, and so on.

Very well said, and, you know, what the EPA is proposing at this point can harm not only businesses that we have talked about today, we have heard a lot about the businesses it would harm, but it could particularly harm seniors. And not just seniors in my district, but seniors across the nation with higher heating bills, higher utility bills, higher pharmaceutical bills, and on, and on, and on.

And so, essentially, whether we want to say it in such frank words or not, but they are proposing a hidden tax on consumers, because somebody has got to pay for all this stuff, and it is going to be the consumer that does that. And you all seem like well-informed witnesses, and I appreciate all of you appearing here today.

I would just like to ask each one of you your opinion of how much you think the proposed regulations are going to cost the average American family. Let us start with Mr. Alford, and go from left to right.

Mr. ALFORD. I think it is going to be a tremendous amount. I think it is going to cause loss of jobs. I think it is going to cause loss of homes. I think it is going to cause education being denied, and good health being paid for. I think it is serious.

Mr. POSEY. Okay.

Mr. ALFORD. I hope I answered it.

Mr. POSEY. Thank you.

Mr. KEATING. I think it is significant. The—when you talk about the link between wealth creation, and a better environment, and improved health, that is absolute. We see that across nations. And it is also critical to understand that increased regulation his productivity the most. There is a clear negative impact on productivity. Study—and study after study shows that. And guess what, productivity is linked to income. So if we want to have not only job creation, but higher incomes, this is not the way to go. It is a clear negative.

Dr. RICE. We are already paying for the cost of ozone pollution, and lowering the standard will benefit the health of many Americans. So just to take the example of where the evidence is most robust that ozone contributes to asthma exacerbations—so take just one asthma exacerbation. You have the cost of a doctor's visit, you have the cost of the medications that the doctor prescribes to treat that asthma exacerbation. You may have the cost of an emergency room visit, if the patient's asthma cannot be controlled with medications. You might have the cost of a hospitalization.

Mr. POSEY. You think these costs are consistent with the upgraded requirement, then?

Dr. RICE. I am saying that the——

Mr. POSEY. My question is how much do you think the cost will be to the average family if this policy is implemented?

Dr. RICE. I am a physician. I am not an expert on the——

Mr. POSEY. Then just say I don't know. That is allowable here.

Dr. RICE. —but there are costs that are equally important that are not being discussed, and those are the human health costs.

Mr. POSEY. Right. That wasn't the question. I would appreciate it if you would answer my question, if you can.

Dr. LEFOHN. Thank you very much for the question. In my particular case, I am a scientist, and so therefore I am not an economist, who understands the cost and the benefit. However, when background ozone contributes major, major role—plays a major role in the total observed concentration, the implication is it is going to take a lot of cost, a lot of reduction effort, to attain whatever level of the standard you are trying to get to. And the point being this, is that the red and the blue—the red, white, and blue figure I showed earlier, with the mostly blue, with a little bit of red, that little bit of red is going to be very costly to get rid of in some of those areas.

So, therefore, even if people say it doesn't matter what background is that it is the total observed concentration that is important. It is the relative contribution of background that will determine the amount of effort and the amount of cost associated with that reduction. Thank you.

Mr. POSEY. Okay.

Mr. HEASTON. I would say that of course the cost is going to show up in the price of goods and services. Anytime regulations go into effect, there is an ancillary cost to that, and so I wouldn't be able to give a number, because that is way out of my field, but certainly it is going to cost the consumers more.

Mr. POSEY. Thank you, Mr. Chairman.

Chairman SMITH. Thank you, Mr. Posey. The gentlewoman from Oregon, Ms. Bonamici, is recognized for her questions.

Ms. BONAMICI. Thank you very much, Mr. Chairman, and thank you to the panel for this very important discussion. I want to start by asking for unanimous consent to enter into the record a letter from more than 1,000 physicians, nurses, respiratory therapists, and public health professionals regarding ozone, and the importance of a protective National Ambient Air Quality Standard.

Chairman SMITH. Okay. Without objection, made a part of the record.

[The information appears in Appendix II]

Ms. BONAMICI. Thank you, Mr. Chairman. Everyone on this Committee agrees that we need clean air, and everyone should agree that we have seen some great improvements in air quality since the passage of the Clean Air Act. And the improvements can be attributed in part to the requirement that the EPA determine air quality standards based on the levels requisite to protect public health, rather than by cost or ease of implementation. Now, that in no way means that those of us who support that determination do not care about businesses or jobs. Of course we do. But the Clean Air Act requires the EPA to set the standard for ozone at a level that will protect public health with an adequate margin of safety.

Now, it seems obvious—for example, Dr. Rice, you are a medical doctor. You don't make your medical diagnosis contingent on the cost of treatment. You don't say to your patient, this is what you can afford, so this is what I am going to diagnose. So can you just talk briefly about the importance of making that determination of what it takes to protect public health in a way that is disconnected from the cost associated? And I do want to save time for another question. Thank you.

Dr. RICE. Thank you, Congresswoman. Yes, the EPA is obligated to set the standard based on a level that is considered to be adequately protecting public health, with an adequate margin of safety, and costs are not supposed to factor into this decision. And I think patient care is a very good analogy, and that is what I am familiar with, and an analogy I would give is if I am making a diagnosis. So, for example, if a patient is in the ICU, I might diagnose them with pneumonia due to a bacterial infection. My diagnosis is not contingent on the costs and the details of the treatment.

And, similarly, I think, with respect to the science on ozone pollution, that is the stage that the medical and scientific community is at right now. We have made a diagnosis. It is clear, and I would say indisputable, that ozone is harmful to human health. And that is——

Ms. BONAMICI. Thank you, Dr. Rice. And I know, since the passage of the Clean Air Act, there have been technological improvements, a lot of steps that have been taken by states and by industry to meet those standards. Dr. Rice, I understand that EPA and others have estimated the benefits by achieving a lower ozone standard, and specifically—and I want to ask you to follow up on your response to Mr. Posey's question.

Specifically, the EPA has estimated that an ozone standard of 65 parts per billion would generate an estimated 19 to $38 billion worth of benefits, including a range of areas from the number of premature deaths avoided, to the number of asthma attacks that can be prevented in children. And we talked about, you know, some of the other witnesses talked about how this would impact jobs and small businesses, but people can't go to work if they are sick or hospitalized. So can you describe some of the other benefits that the EPA and others have estimated from an ozone standard—let us just take the range of 65 to 70 parts per billion. What are some of the savings in costs——

Dr. RICE. Certainly. So the EPA has taken into account, as you said, the savings from avoided premature mortality, the savings from avoided asthma admissions. There are also financial benefits that the EPA and others have taken into account in their analyses, looking at the medication use associated with asthma exacerbations and respiratory illness. Avoided missed school days in children, avoided work days in adults who have respiratory disease, adult use for medication for asthma, and other exacerbations.

In addition to the EPA analysis, there is a different kind of analysis that was done and published in 2012 that looked at the difference between full attainment of a 65 part per billion and a 75 part per billion ozone standard, and found sizeable differences in mortality benefits, acute respiratory symptoms, and also millions of lost school days in children.

Ms. BONAMICI. Thank you. And I have just a few more seconds. I want to ask Mr. Heaston, I hope I pronounced your name correctly—it is my understanding that the EPA is planning to revise its exceptional event rule, which is a tool to handle events like wildfires and ozone intrusions, stratosphere ozone intrusions. What recommendations would you have for EPA on revising that rule?

Mr. HEASTON. Well, we would certainly want to encourage it, as—at—because there are different ways that—like, meteorology plays a part in whether you could have a day—you could, you know, you can just have bad meteorology that causes you to have an exceedance that exacerbates the issue, and there may not be any control for that. And those kinds of things would be important. Obviously wildfires can also have an effect on that. They have already started to work in that area cooperatively to address it, especially—PM is another area where we are already working to do that.

Ms. BONAMICI. Thank you so much. My time has expired. I yield back. Thank you, Mr. Chairman.

Chairman SMITH. Thank you, Ms. Bonamici. The gentleman from Oklahoma, Mr. Bridenstine, is recognized for his questions.

Mr. BRIDENSTINE. Thank you, Mr. Chairman. The new proposed National Ambient Air Quality Standards for ozone, which would lower the allowable level to—the ground level ozone to 65 parts per billion will cost the American economy $1.7 trillion—I think, Mr. Alford, you mentioned that—$1.7 trillion from 2017 to 2040, according to a recent report from NERA Economic Consulting. With unanimous consent, Mr. Chairman, I would like to enter this report into the record.

Chairman SMITH. Without objection, that will be made a part of the record.

[The information appears in Appendix II]

Mr. BRIDENSTINE. So that is $1.7 trillion is what it will cost the GDP from 2017 to 2040, according to this NERA Economic Consulting report. I would also ask unanimous consent to place into the record a statement from the American Chemistry Council, and a letter to EPA Administrator McCarthy signed by 11 governors, including my own governor, Mary Fallin from Oklahoma.

Chairman SMITH. Without objection.

[The information appears in Appendix II]

Mr. BRIDENSTINE. So in Oklahoma—my entire state of Oklahoma is within attainment, and we are very proud of that. And I would also tell you that even though we are in attainment, we are reducing ozone levels as we speak. The mayor of Tulsa, Dewey Bartlett, has been working on this and his administration. Our county commissioners have been working on this, with their administrations.

This is important to us, because in Tulsa, Oklahoma, we love our city. We—the suburbs, we all want to see our region, and want to see the State of Oklahoma do well. I can tell you Governor Mary Fallin is committed to this. This is a big deal for all of us from Oklahoma. I would also say we are in attainment. This is not something where we need, you know, bureaucrats from Washington, D.C., coming into the State of Oklahoma to tell us that we need cleaner air, because guess what, we want cleaner air, and we are working towards that without the bureaucrats in Washington, D.C., telling us how to do it.

I do have some questions, just out of curiosity, from some of the stuff I have heard and the testimony, for Dr. Rice. As you know, we are working to decrease ozone in Oklahoma. Nationally has ozone been decreasing or increasing since 1980?

Dr. RICE. So nationally ozone has been overall decreasing. There have been some ups and downs, because, as I mentioned before, climate also plays in a role in affecting ozone levels, and that might be part of the reason for some of the variability.

Mr. BRIDENSTINE. So have the asthma rates been increasing or decreasing?

Dr. RICE. So asthma rates have been increasing.

Mr. BRIDENSTINE. So ozone has been decreasing, and asthma rates have been increasing?

Dr. RICE. That is right.

Mr. BRIDENSTINE. Do you have an explanation for that?

Dr. RICE. The question of asthma prevalence rising is a separate question. That has to do with what causes asthma. There is no overall conclusion from the scientific literature that ozone is a cause of asthma and makes asthma worse.

Mr. BRIDENSTINE. So, clearly there is no correlation between ozone increasing and higher rates of asthma?

Dr. RICE. So you are, again, talking about the prevalence of asthma, how many people have asthma, but the issue of asthma exacerbations is a separate issue, and ozone has been found to exacerbate asthma. And asthma exacerbations, when you correct it for the number of people who have asthma, that is—to my knowledge has not been changing.

Mr. BRIDENSTINE. So ozone is an outdoor air pollutant. Most people spend more time indoors, and rarely are exposed to significant levels of ozone. What is the role of indoor sources for the increase of asthma incidences? Like the indoor sources for the increase of asthma.

Dr. RICE. So, again, you are talking about the increased incidents of asthma, which is not related to ozone. And I am not sure I agree with your statement that people don't have significant outdoor exposures. I think especially children, who spend time outdoors playing, have—spend a large part of their day outdoors, and they should.

Mr. BRIDENSTINE. Are there indoor sources that create more asthma problems?

Dr. RICE. Of ozone?

Mr. BRIDENSTINE. No, are there indoor—like—when—I am talking about the correlation. So are there indoor exposures to things that create more asthma problems, or that exacerbate the asthma that people already have?

Dr. RICE. Absolutely. There is very large literature on that as well. There are a number of things that have been identified that make asthma worse. One of them is indoor allergens, so allergic people tend to be more sensitive to things that they are allergic to, and that can make their asthma worse. So if they are allergic to mice or cockroaches, for example, that has been found to exacerbate asthma. That is just one example of an indoor exposure.

Mr. BRIDENSTINE. Data shows that hospital admissions for asthma are actually higher in the winter, when ozone concentration levels are typically at their lowest. Can you explain that?

Dr. RICE. So, as I mentioned, there is a lot of different exposures that contribute to asthma, and ozone is just one of those exposures. It is complicated.

Mr. BRIDENSTINE. In your written testimony, you have a figure entitled "Exposure Response Curve for the Relation Between Exposure to Ozone and the Risk of Death from Respiratory Causes". The X axis—in terms of the daily one hour maximum, the X axis, is a daily 1 hour maximum ozone level. Are you basing your recommendation for the sixty parts per billion with the one hour or the eight hour maximum ozone level, which is what the EPA uses?

Dr. RICE. I am not basing my recommendation of either of those things—have to do with how the exposure interval is defined for setting the standard. I am basing my recommendation on the overall collected data, looking at ozone measured in different ways, looking at different exposure intervals, whether it is one day averages, one year averages, six hour exposures, as you discussed, or one hour exposure——

Mr. BRIDENSTINE. If it is based——

Dr. RICE. —overall——

Mr. BRIDENSTINE. If it is based on the eight hour standard, as the EPA's standard, this means that your recommendation—if your X axis is a one hour standard, that means your recommendation would actually be below sixty parts per billion, is that correct?

Dr. RICE. I am not sure I understand your question.

Mr. BRIDENSTINE. So the EPA uses an eight hour standard, you are using a one hour standard. If you expand it to an eight hour standard, you could actually go higher than sixty. But you are using a one hour standard, and saying sixty, which means your exposure would actually be, for an eight hour standard, even lower than the sixty parts per billion?

Dr. RICE. So that particular study—first of all, as I said, I am not recommending a standard based on any particular average. That decision is made by others. I am talking about ozone exposures and health effects. And I think what you are referring to is that if you just pick one hour, you could have a spike in ozone. If you pick eight hours, that eight hour average could be lower, is that what you are saying, than what that one hour spike——

Mr. BRIDENSTINE. I saw—Dr. Lefohn, you smiled there. Did you have something to add?

Dr. LEFOHN. Maybe I shouldn't smile. If, in fact, the sity parts per billion was referring to that particular figure, and I am not sure that that was the case——

Mr. BRIDENSTINE. The one hour standard?

Dr. LEFOHN. The one hour daily max that was used in the time series, then the eight hour timeframe would be a lower concentration, which I think is what you are saying. If, in fact, Dr. Rice is saying there is a whole group of experiments that she is looking at, and she was giving the example of the Jarrett results, then I would question the use of that one particular study because it was a 1 hour daily max. But if she says there are lots of others, that is fine.

Mr. BRIDENSTINE. And I would just like to finish, Mr. Chairman, again, the State of Oklahoma is working very hard to reduce ozone, and we are doing it even though we are already in attainment. And I think that is an important point that everybody here needs to recognize.

Chairman SMITH. Thank you, Mr. Bridenstine. The gentleman from Texas, Mr. Weber, is recognized.

Mr. WEBER. Thank you, Mr. Chairman.

Dr. Rice, if you had a magic wand, and you could just wave that rascal, no costs, no problems, what level would you like ozone to be at?

Dr. RICE. That is a very good question, Congressman. The evidence around—I think what you are asking me is what about the health effects in ozone levels below 60, and how far down do we go? There is some evidence of health effects below a level of 60 parts per billion, so if I had that magic wand, if I could have everything I, you know, if there were—I would love to be able to just take ozone out of the picture altogether, but that is not possible. And there is no—the evidence surrounding health effects below a level of 60 parts per billion is not strong.

Mr. WEBER. Thank you for that. And, Mr. Chairman, I forgot that I have a health study I want submitted in the committee record. It is from the "Journal of Allergy and Clinical Immunology", into the record, if that is possible?

Chairman SMITH. Without objection.

[The information appears in Appendix II]

Mr. WEBER. Thank you. So you think there are health effects lower than 60. How often do you think it ought—that level should be reviewed?

Dr. RICE. So as I said, the evidence of health effects below a level of 60 parts per billion are not strong, so I don't feel comfortable stating that—definitely health effects below a level of 60 parts per billion, based on the evidence.

Mr. WEBER. Do you believe that science—that the data behind that should be made open to the public?

Dr. RICE. That data is open to the public.

Mr. WEBER. Okay. You are a medical doctor is——

Dr. RICE. Um-hum.

Mr. WEBER. —is that right? You understand lung disease. Your specialty is——

Dr. RICE. Pulmonary and critical care medicine.

Mr. WEBER. Pulmonary and critical care medicine?

Dr. RICE. Um-hum.

Mr. WEBER. Dr. Lefohn, you are a scientist, you said. You——

Dr. LEFOHN. I am, sir.

Mr. WEBER. You am, sir. You did research, and you named a whole bunch of people in your statement. Can you go back over those groups again who you did studies for?

Mr. WEBER. Yes. I designed, with Dr. Milan Hazucha, the Schlagele exposures that were used.

Mr. WEBER. Okay, but you named a whole bunch of groups, tribes and government——

Dr. LEFOHN. I am sorry.

Mr. WEBER. Yeah.

Dr. LEFOHN. That—those are the groups that I have done research——

Mr. WEBER. You have done research for? So you are a scientist—you are a research scientist. Okay. Can you name those groups very quickly? I am getting——

Dr. LEFOHN. You bet.

Mr. WEBER. —before I run low on time.

Dr. LEFOHN. Yes. Okay. I have done—I have assisted the American Lung Association with the State of Air report that, every year——

Mr. WEBER. Just the group.

Dr. LEFOHN. Okay. The Forest County Potawatomi Group in Wisconsin, the U.S. Forest Service, U.S. EPA, Congress, with the Office of Technology Assistance, the White House, dealing with the National Acid——

Mr. WEBER. Okay.

Dr. LEFOHN. —Precipation.

Mr. WEBER. That is plenty. Thank you for that. So you are a research scientist, you probably don't know many things about lungs, and—what did you call that, Doctor? What kind of diseases? Pulmonary——

Dr. RICE. And critical care——

Mr. WEBER. Critical care. As a research scientist, Dr. Lefohn, you probably don't know much about that.

Dr. LEFOHN. I do.

Mr. WEBER. You do?

Dr. LEFOHN. I do.

Mr. WEBER. So you have been studying that too?

Dr. LEFOHN. I have.

Mr. WEBER. Good for you. You need to get a TV maybe to use in your spare time. Dr. Rice, you heard Dr. Lefohn's research stats, that naturally occurring ozone, as I understood the figures, is somewhere between 40, 50 percent background ozone in some of these areas, which makes up the numbers that we are looking at. Is that accurate, Dr. Lefohn?

Dr. LEFOHN. In some cases, it is 80 to 90 percent.

Mr. WEBER. Well, I wasn't going to go that high, but just to say as a general rule it is 40 to 50 percent. So you are aware of that, Dr. Rice? You are also aware, as the gentleman from Oklahoma said, that ozone is going down, but asthma is going up, and you don't know what causes asthma?

Dr. RICE. You asked me a number of different questions, and I will try to address——

Mr. WEBER. Well, you are aware of his——

Dr. RICE. So——

Mr. WEBER. —statistics, I take it?

Dr. RICE. I am aware——

Mr. WEBER. Okay.

Dr. RICE. —of his studies——

Mr. WEBER. And you——

Dr. RICE. —and I am aware of other studies that have given other projections of the——

Mr. WEBER. Okay.

Dr. RICE. —amount of background ozone. Let me finish, please, and try to answer your question.

Mr. WEBER. My only question was are you aware?

Dr. RICE. All right.

Mr. WEBER. Thank you. So you know that ozone is down, asthma has not gone down. Would you agree that if there are more stringent controls put on business, that is going to drive the price up, Dr. Rice, of doing that business?

Dr. RICE. I am a physician. That is not what I am here to talk about. I am here——

Mr. WEBER. Okay. But if they have to add technology to decrease ozone, it is going to cost something?

Dr. RICE. Um-hum. You also mentioned that—I just wanted to——

Mr. WEBER. Is that——

Dr. RICE. —clarify for the record that you said asthma is going up. Again, ozone has nothing to——

Mr. WEBER. No, I got that.

Dr. RICE. My testimony has nothing to do with the asthma prevalence.

Mr. WEBER. But here is what I am driving to. So we don't know cause and effect. We do know there is a lot of natural occurring background ozone. It is going to drive the cost up. Stringent regulations are going to drive the cost up. And as Mr. Alford said in his remarks, and I happen to agree with him, it is going to cost billions of dollars, lost jobs. That is going to cost money to consumers who cannot afford health care, and so their level of health care is going to go down as a result of this, and we really don't know that it is going to have a positive effect on asthma.

Dr. RICE. Congressman, I respectfully disagree that we don't know cause and effect. I think the evidence is very clear that ozone exacerbates asthma.

Mr. WEBER. I said cause, I didn't say—cigarette smoking does too. Are you on a kick to do away with cigarettes?

Dr. RICE. That is a different issue.

Mr. WEBER. Okay. I am just blowing smoke, aren't I? Okay. I got it. Mr. Chairman——

Dr. RICE. What do you think I advise my patients——

Mr. WEBER. Okay. I yield back.

Chairman SMITH. Thank you, Mr. Weber. The gentleman from Texas, Mr. Babin, is recognized.

Mr. BABIN. Thank you, Mr. Chairman. I believe that we have a duty to be responsible stewards of our environment, and I think that is reflected in the tremendous strides we have made with air quality over the last few decades. I can remember back in the '60s and '70s, as an avid outdoorsman, some of the pollutants that we have had in our water and our air, and we have made tremendous strides in that regard. However, there is no concrete evidence to support a lower standard for ozone before we have even complied with the last standard. If anything more research needs to be done. Based on this, it makes no sense that the Environmental Protection Agency is proposing one of the most costly regulations in U.S. history on a very limited set of studies. The EPA should not be rushing to issue this new standard.

Now I want to draw attention to a slide, and talk a little bit about my district, and how this is going to impact us. As you see up here, I have Texas 36 District, and we have the notoriety, or the fortune—the good fortune to—I should say to have more chemical and refining plants in our District 36 than any other district in the United States. We have the second largest manufacturing industry in the state, the chemical industry, $164.6 billion. We directly employ 9,393 individuals in District 36 alone. We pay out $934 million in wages in the district. We have an average wage of $99,386 in the state. This is 94 percent higher than the state average in Texas. We generate $94 million in federal taxes. We invest $4.982 billion to build and update equipment and facilities in the State of Texas. 47 billion in industry products are shipped to global customers from the State of Texas. This generates an additional 1,224 jobs in the plastics and rubber products industry.

Is it worth, and I am asking all of you panelists, and I appreciate all of you being here, whichever side of this issue you are on, is this worth putting all of this at risk, just in District 36 alone, not counting the rest of the nation, all of these jobs, all of these industries, and the overall economy of our nation, is it worth it? I would just like to say—to ask each one of you panelists that question.

Mr. ALFORD. No, it isn't, Congressman. Senator Barbra Mikulski told us in a meeting about NAAQS back around 2000, 2001, she said, I am looking at this NAAQS situation four ways, is it sound science, the economic impact, which you just explained up there, is it measurable and achievable, and for national security? And I think this move to lower NAAQS further flunks all four of these categories.

Mr. BABIN. I appreciate that answer. We produce about 63 percent of all strategic aviation fuels in this area alone.

Mr. ALFORD. Looks like a nice place to live.

Mr. BABIN. It is. Lots of jobs. Mr. Keating?

Mr. KEATING. No, it is not worth it. It makes no sense, when you look at—your district is a prime example of the good things that are going on in an otherwise very tough economy. Why would we want to put that in jeopardy? When you look at, again, the increased cost of regulations, the negatives for growth, for productivity, for investment. Study after study shows this. You talk about exports. That is a wonderful thing. Wouldn't we want to boost our exports, rather than exporting more jobs and businesses? So no, it is not worth it.

Mr. BABIN. Doctor?

Dr. RICE. Thank you, Congressman. First, I would argue that the question of whether it is worth it shouldn't be factoring into the decision of what a safe standard is for the American public. And the evidence has shown that the current levels are not protective of public health, and that a level of 60, or in that range, is more protective of public health. So, setting the implementation details aside, the second point I would like to make is that when we look at history, we look at the Clean Air Act, and a number of people in this room have commented on the success of the Clean Air Act over the last 10 to 15 years, and there have been a number of economic analyses of the benefits of the Clean Air Act, and those have concluded that the Clean Air Act may be one of the best financial decisions our government has ever made.

Mr. BABIN. Yes, sir?

Dr. LEFOHN. Yes. Let me be clear, our results for background ozone that our international team published in late 2013 agrees with EPA's policy assessment numbers that it published in 2014. There is no disagreement. Background is very important. Those dots I showed in that figure were from EPA's own analysis. The bottom line is as follows. We have made great advances in reducing ozone. The problem we are now getting into is that background itself is beginning to rear its head. We are going lower and lower and lower, and we are at that level—and let me explain.

What EPA did was they ran a model, and they ran their model—and this is, let us say, the concentrations of ozone. Low end, high end. As you reduce emissions, you would assume that the high end goes down toward the low end, and the low end stays constant. What, in fact, happened, and impacted in a dramatic way the epidemiological risk assessment, was that the high end came down, and the low end came up, and they met in the middle. In the middle was where most of the risk was associated with, which is predominated by background ozone.

Mr. BABIN. Thank you. Mr. Heaston?

Mr. HEASTON. I would say that the new NAAQS is not necessary because the government needs an opportunity to just do a good job on what we have got in front of us, and let us just work on doing that from a common sense approach. Let us try to meet the 2008 standard, and leave this other one for after, because what I see is negligible gain to the actual health benefit when maybe a job might be a better control measure than anything I can put in place to try to meet an ambient standard.

Mr. BABIN. Well stated. Thank you all very much, I appreciate it.

Chairman SMITH. Thank you, Dr. Babin.

Mr. BABIN. Thank you, Mr. Chairman.

Mr. BABIN. And, Dr. Lefohn, let us just say that is the first time I have ever seen a Slinky used for that purpose, but it is good.

Chairman SMITH. I am glad people recognized it.

Chairman SMITH. The gentleman from Michigan, Mr. Moolenaar, is recognized for his questions.

Mr. MOOLENAAR. Thank you, Mr. Chairman, and I would like to ask unanimous consent to submit for the record a letter from Michigan Governor Rick Snyder, as well as a technical submittal from Dan Wyant, the Director of the Michigan Department of Environmental Quality, that was sent to President Obama on February 26.

Chairman SMITH. Without objection.

[The information appears in Appendix II]

Mr. MOOLENAAR. Thank you, Mr. Chairman. In this letter, and I guess, Mr. Alford, I would like to address this to you, if that is okay, Governor Snyder states that more stringent standards could thwart growth and business investment. And, obviously, we want to be good stewards of our environment in Michigan, but the National Association of Manufacturers estimates the proposal before us would cost approximately 20,000 jobs a year. And I just wanted to get your perspective on this effect, possibly on Michigan, and what these more stringent ozone standards—how that might encourage or discourage economic growth? Because some people are arguing that that would actually encourage economic growth.

Mr. ALFORD. I lived in Detroit five years back in the late ’70s, early ’80s, met my wife in Detroit. It would have a profound effect, once again—and Detroit, you keep waiting for it to hit bottom, well, there is going to be a new bottom caused by that. There is so much opportunity to bring—people have the skills in Michigan. There is so much opportunity to bring new business, because the people already there are prepared.

Mr. MOOLENAAR. Sure.

Mr. ALFORD. But—this way, with these standards, would be a shame.

Mr. MOOLENAAR. Okay. Thank you. Mr. Keating?

Mr. KEATING. Yeah, I would just like to note real quick that we do an index each year where we rank the states according to their policy climates, and Michigan has improved rather dramatically, and kudos to the state, but this is an instance where you would have the federal government working against what you have been doing on the state level to improve the environment, so it clearly would be a negative, I would say.

Mr. MOOLENAAR. Okay. Thank you. And, Mr. Heaston, I would like to ask your thoughts on this. The background ozone levels—our experts in our state have noted that lowering the standard below the 75 parts per billion would make this compliance very difficult, almost impossible, for a state like Michigan, just due to background ozone levels. Can you comment on either in particular with Michigan, or with other states who have a strong manufacturing base what this might mean, in terms of how they could comply?

Mr. HEASTON. Well, I think that mainly the areas that may come under it as a result of the new NAAQS, the new non-attainment areas, you are going to find that a lot of them are going to be transport impacted from maybe some other parts, and also from the non-anthropogenic emissions. So I think that we are going to have to determine what is a number that you can live with, if ambience ozone levels are higher? And I think, like, in our district, the 60 ppb is probably very close. I have no way to come into attainment without South Coast making dramatic and draconian type cuts in the L.A. basin. And so I mean, when you are a rural area, or where the population density is down, and you have nothing to control, I don't know how you get there.

Mr. MOOLENAAR. Thank you. Anyone else like to comment on that? I guess the main question I am asking here is, if we would agree that it is—the 75 parts per billion, it hasn't even truly gone into effect, and, you know, measurable ways of examining how that is affecting states, I guess the question is, you know, what are the consequences for setting a standard that isn't really a real world achievable standard for states who are trying to comply with this across the board?

Dr. RICE. Congressman, I would like to discuss that——

Mr. MOOLENAAR. Sure.

Dr. RICE. —issue. So, back in 2006, when the Bush Administration asked the Clean Air Scientific Advisory Committee to review the evidence, and to develop a recommendation for what an appropriate standard would be, the committee recommended a range of 60 to 70 parts per billion then, and that was almost ten years ago. So, yes, we are dealing with the implementation of a standard that was established then, but the evidence that was available even at that time was in favor of—was consistent with health effects in the 60 to 75 parts per billion range.

So I guess the point I am trying to make is there is nothing magic about the 75 parts per billion standard. Even when it was established, the scientific community did not feel that it adequately protect public health. And in terms of looking at health effects, and analyzing whether this standard is appropriate, one of the advantages of the research that I do, looking at what we call observational data, so things that have happened, so looking at historical air pollution data and health outcomes, we have a breadth of ozone concentrations even within just the city of Boston, where I do most of my research, but across the country we have a wide range, and day to day ranges. So that allows us to look at health effects well below the 75 parts per billion. And we already have plenty of evidence to support that the health effects are serious——

Mr. MOOLENAAR. Now, I guess——

Dr. RICE. —that range.

Mr. MOOLENAAR. Just, Mr. Chairman, if I may follow up?

Chairman SMITH. Yes, Mr. Moolenaar.

Mr. MOOLENAAR. When you use terms like the scientific community, or when you say plenty of evidence, my sense is there are probably scientists, in fact even some here with us today, that wouldn't agree with your conclusions, and would say that the evidence is inconclusive. Would you acknowledge that?

Dr. RICE. Certainly.

Mr. MOOLENAAR. Okay. So——

Dr. RICE. So when I am talking about the scientific community, I can give you some examples——

Mr. MOOLENAAR. Right. Well, no, I know, but I bet there are examples in the scientific community that would not support your premise, and—but let me just—because I know, Mr. Chairman, you are trying to conduct this hearing, and get everybody involved, I appreciate all of you appearing. I am very concerned if we change the standard at this point, because I don't believe the scientific community is unanimous on this, and I do think that the consequences of putting states in non-attainment, and the chilling effect on the economy is not appropriate at this time.

Chairman SMITH. Thank you, Mr. Moolenaar. The gentleman from California, Dr. Bera, is recognized.

Mr. BERA. Right. Thank you, Chairman, and thank you, Ranking Member, for having this hearing. You know, as a fellow physician, you know, it is incredibly important that we take standards to address respiratory effects, and address asthma rates. I am empathetic to concerns about increased economic costs, and, you know, impact on jobs, but, you know, Dr. Rice, I think you would probably concur that, you know, the detrimental cost to asthma, the detrimental cost to, you know, increased respiratory and pulmonary disease also have a huge economic impact. And I don't know if you can quantify that, but, again, we know the lifelong impact of, you know, these increased asthma rates and so forth.

Dr. RICE. Thank you for your question, Dr. Bera. Absolutely. Many of the cost analyses that have been discussed so far today have not taken the human health costs of implementation, or of not implementing a stricter standard, into account. And those that have examined the health effects have found enormous health benefits associated with lower ozone standards, and those are in the form of savings from the use of medications to control asthma or COPD, lost work days that are avoided when people can go to work because they are feeling better, because the air quality is better. Kids can go to school. The cost of hospitalization for respiratory disease. And then there is, of course, the difficult to quantify costs of human suffering when people die as a consequence of higher ozone levels. Those are very important.

Mr. BERA. So if we are doing a fair economic analysis, we also should clearly take a look at the prevention by impacting ozone standards, impacting asthma rates, impacting community health, and that would give us a much greater economic picture?

Dr. RICE. Absolutely. I agree with that. Thank you.

Mr. BERA. I apologize if you have already touched on some of these cases, but, by upgrading our ozone standards, can you quantify the health impact, in terms of reduction in asthma rates, or——

Dr. RICE. I can give some examples. I could give——

Mr. BERA. Great.

Dr. RICE. —the example of—so each study uses a different methodology, and they are going to arrive at different numbers, but one study, for example, by Berman and colleagues at Johns Hopkins looked retrospectively at asthma, and other health effects under different ozone standards. So, just to give an example, this analysis looked at how many lives would be saved if we fully adhered to the current standard of 75 parts per billion. And they estimated that approximately 2,000 would be saved just from the respiratory mortality component at 75 parts per billion, if we actually were there. And then if we went down to 70 parts per billion, almost 4,000 lives would be saved. And that increases to 7,000 at 60 parts per billion, so triple the benefit. Acute respiratory symptoms, and that includes things like asthma and COPD exacerbations, about three million reduced exacerbations if we implemented the 75 parts per billion, increasing to almost—to more than three times that, 11 million exacerbations each year. This is going back to 2005.

The EPA used a different approach, looking forward, at 2025, and estimated at 65 parts per billion, 4,300 premature deaths, and almost a million childhood asthma attacks would be avoided. Just some examples.

Mr. BERA. So, again, this is incredibly important, right? I mean, you are talking about children's lives, you are talking about huge economic impacts when you are talking about millions of potential exacerbations that are now mitigated by doing something that is actually a good thing to do. If we look at the current science, you know, the current standards don't reflect the current science, is that correct? Is that an accurate statement?

Dr. RICE. I would agree with that. That was the point that I made earlier as well, that even when the current standard was set, the Clean Air Scientific Advisory Committee had recommended a lower standard.

Mr. BERA. Okay. So, again, you know, part of our job as scientists, part of our job as physicians, is to provide the best science. And then what we should be doing, as Members of Congress, is taking that science, taking the recommendations of the experts, and acting on that. So, again, thank you for your testimony, and thank you for your time.

Dr. RICE. Thank you.

Chairman SMITH. Thank you, Mr. Bera. Are you finished? The gentleman from Alabama, Mr. Palmer, is recognized.

Mr. PALMER. Mr. Chairman, I would like to introduce into the record a letter from the Governor of Alabama, the Honorable Robert Bentley, addressed to the Honorable Gina McCarthy of the EPA.

Chairman SMITH. Without objection.

[The information appears in Appendix II]

Mr. PALMER. Thank you.

Mr. Heaston, reductions in ozone levels can be achieved by a variety of methods, including control technologies and control measures. Ozone control strategies generally target nitrogen oxides and volatile organic compounds, which are the primary contributors to ozone formation at ground levels. Unfortunately, the EPA has not been able to identify how the proposed standards will be met. Despite intensive review of available control technologies, the EPA is forced to heavily rely on controls that could not identify or predict literally unknown controls.

If the EPA can't even point to controls capable of almost half the emissions reductions needed in the east, or all of the reductions required in California to meet these stringent proposed standards, this sounds like a shoot first, ask questions later rulemaking. Should we be imposing this much burden on the American people when the EPA doesn't even know how this rule can be accomplished?

Mr. HEASTON. Thank you. The broader question, I think, is the use of the black box, it is just a holding mechanism, so that you can go through the process and meet the requirements of the Clean Air Act. And they have to approve them, without any backup to it. And, I mean, I personally am glad it is there as a tool, but the reality is that the technology may not be developed, it may not be cost-effective, and it is—you are looking into the future with promises of some sort of a deposit that you may not be able to withdraw later on if they are not there. And that is one of the concerns I have. You are just going to make the black box a bigger part of your attainment strategy, and that is not the way we should be going.

Mr. PALMER. Well, I worked—prior to being a Member of Congress, I had a real job. I had several real jobs, one of which was in engineering and environmental systems. And one of the estimates here is that EPA's cost benefit analysis on the ozone proposal caps the cost of unknown controls, again, controls that don't exist, at $15,000. And having worked in environmental systems, designing and building pollution controls that our company did, I can't think of a single thing that we could do for $15,000. So is your experience in implementing unknown controls, does that sound reasonable?

Mr. HEASTON. No, it does not.

Mr. PALMER. Thank you. I also want to address something, Dr. Rice, that you brought up about the need to do this to improve health. Would you agree that an individual's health is directly impacted by their economic or income status?

Dr. RICE. Absolutely, yeah, I would agree with that.

Mr. PALMER. So lost jobs would impact their health?

Dr. RICE. It certainly could——

Mr. PALMER. Thank you.

Dr. RICE. —affect someone's health.

Mr. PALMER. I think it would too, particularly when you look at the preponderance of data on who are likely to have asthma. It is males living below the poverty line, unemployed.

I want to go back to this other issue, Mr. Heaston, with you. I also ran a think tank, and every four years we put out a report on environmental indicators for Alabama and the United States, and

Alabama has done quite well in improving air quality, particularly in Birmingham, where I live, which was known as the Pittsburgh of the South. We were a steelmaking company. In the '60s you could see the air you were breathing. We have made great progress, despite the fact that the EPA keeps changing the standards. We still meet them. This new standard, thought, makes very little sense to me, particularly since the EPA admits the technology doesn't exist.

Do you have any knowledge of any unknown controls in use right now, in practice, or are they things like—are these unknown controls more in the line of shutting down a power plant, or mandatory electric cars? Is that the black box that we are talking about?

Mr. HEASTON. I would never, ever admit to that as control strategy, that I am going to try to shut down some industrial source—not in my district. Now, it might be in other districts that have no choice, but it certainly wouldn't be a strategy that I would employ. My job is to try to figure out how to make the economics and the balancing of human health work together, because they are not exclusive to each other. You have to have them both in order——

Mr. PALMER. Well——

Mr. HEASTON. —find a way to pay.

Mr. PALMER. —even with that, it wouldn't accomplish the objective because so much of the ground level ozone occurs naturally——

Mr. HEASTON. Right.

Mr. PALMER. —particularly in the South, where you have got a number of warm, windless days, and a high density of forest. So, with that, Mr. Chairman, thank you.

Chairman SMITH. Thank you, Mr. Palmer. And the gentleman from Ohio, Mr. Johnson, is recognized.

Mr. JOHNSON. Thank you, Mr. Chairman. I found it interesting a little earlier, when Dr. Rice made an analogy about the EPA's need to set standards for ozone, comparing that to her requirement, as a physician, in rendering a diagnosis, that your diagnosis does not address the cost. That I actually would agree with, from a health care perspective, but I submit that most physicians would certainly agree that the course of treatment for whatever that diagnosis would be would certainly be a cost consideration, because a physician is not going to be willing to render that treatment for free, I don't believe.

And I think what we are looking at here is the standards being set by the EPA, those are a course of treatment. They are not the diagnosis. I look at the staggering statistics coming out of the American Petroleum Institute that says that these new ozone rules—and we are talking about just my state, first of all. 204.3 billion gross state product loss from 2017 to 2040, 218,415 lost jobs. Across America we are talking about 3.4 trillion in GDP per year from 2017 to—I am sorry, during that time period, and 2.9 million fewer jobs, or job equivalents, per year on the average through 2040. The economic implications of this are staggering. They are profound, and I think we gloss over those way too quickly.

Mr. Alford, the EPA administrator, Gina McCarthy, wrote an op-ed saying that the agency's air standards attract new business, new investment, and new jobs. Is that what businesses have found?

Mr. ALFORD. Not at all, sir. The regulations prevent jobs, prevent business growth. Onerous regulations, regulations that may—have no economic sense whatsoever are crippling.

Mr. JOHNSON. Yeah.

Mr. ALFORD. And let me say, I have a deep appreciation of the improvement in our air quality. You know, I played rough, tough football in Los Angeles back in the '60s, where it was just terrible. Playing in 102 degrees, and someone is trying to take your head off. So I have a deep appreciation for the progress we have made. I think maybe we may be getting it a little too overboard.

Mr. JOHNSON. Okay. Mr. Keating, do you have a response to that?

Mr. KEATING. Yeah. I just—I agree with Mr. Alford, and I think it is important to note, for example, the NERA study. That really is the most, I think, comprehensive look at this at—so far. Includes any kind of benefits, if you will, increased jobs that come from the environmental side of things. So when you—when they talk about the total loss of jobs, let me look real quick, in terms of 1.4 million jobs per year, those factor—that includes the benefit, so that is the net loss there.

Mr. JOHNSON. Okay.

Dr. RICE. Mr. Johnson——

Mr. JOHNSON. Mr. Alford—ma'am, I have got some other questions here, thank you. Mr. Alford, the whole state of Ohio, under these new ozone rules, would be found in non-attainment. Some of the counties would be unmonitored counties that are anticipated to violate a 60 ppb standard based on spatial interpolation. So could these stringent ozone standards hurt economic development in areas that are in attainment?

Mr. ALFORD. Yes, sir. Again, the example of Baton Rouge, which had just got in attainment, but people fear that they are going to be out of attainment if these new rules come in. So prospective businesses from abroad are looking at Baton Rouge, I am sure they would be looking at Columbus or Cincinnati, but if there is a chance that you are going to be out of attainment, all bets are off.

Mr. JOHNSON. But in areas that are in attainment—we conduct commerce all over this country. Goods are produced in one place, they are shipped across the country as raw materials for other places. The point I am making is that the areas that are found not in attainment——

Mr. ALFORD. Um-hum.

Mr. JOHNSON. —they are not the only ones that are going to suffer. The whole country is going to suffer under this.

Mr. Chairman, I have exceeded my time, and I will yield back.

Chairman SMITH. Thank you, Mr. Johnson. And we will go to the gentleman from Washington State, Mr. Newhouse, and is recognized for his questions.

Mr. NEWHOUSE. Thank you very much, Mr. Chairman. First of all, let me say I appreciate all of your participation this morning in this conversation. It is very important. I am from the State of Washington, and I just—something you said, Mr. Heaston, piqued my interest.

Washington, like other areas of the country, is exposed to what is a good deal of ozone and other particulate matter from other countries, foreign countries. Now, EPA has the authority to address this issue in its attainment designations, but, if you could, can you describe how EPA accounts for international border pollution? I am not saying L.A. is another country, but, given that Washington, like other areas of the country, we can't exercise control over foreign sources. And kind of as a follow-up to that, does EPA, as far as you know, provide any implementation flexibility so it doesn't punish states that violate standards due to that outside air—that they have no control?

Mr. HEASTON. Currently there is not a whole lot that can be done about—especially the stuff that comes over from overseas. I think more dramatically, if you look at the Mexico-U.S. border, like, for instance, down in Imperial County, down by the Salton Sea, the impact there is that they can't sometimes put in a business without getting offsets, and so they have gone to drastic ways—not through anything EPA did to help them, but through their own ingenuity, went into Mexico, put a gas pipeline so they could get gas into the homes, so we could get them to quit burning the wood and other debris that they use to heat their homes, and then tried to find a way to take credit for those kinds of reductions.

I mean, that is the kind of things that we have to go to, even in the States of California, just to get a project sited. And, to me, that—it points to a bigger issue when you go to the offshore stuff, because we don't have any way to control that. And if businesses close here—for instance, if the cement industry was to close, and I think they have made the argument, many times, that they will just produce the cement over in Asia, and you still get the emissions back—coming back to the other way. So it is kind of a catch-22 for them, but there is a very limited ability to deal with those kind of emissions.

Mr. NEWHOUSE. Thank you, thank you. Mr. Alford, the EPA's proposed standards will make it, I think, I have heard today, harder to get necessary permits to manufacture goods, build critical infrastructure like roads, and—especially in my state, as well as others, increase cost of energy on all businesses and households. In fact, the study that has been cited a couple times looks to show that Washington State would put costs about $16 billion by the year 2040, even though it is projected all of our counties will be in attainment.

So I guess my question is what happens to permitting for new and expanding businesses throughout the country when these standards are set to close to background levels, and how will the proposed standards hurt economic development in states that are projected to be in attainment? I mean—any idea what those economic impacts might be?

Mr. ALFORD. It would be negative, I would believe. You know, permitting is a catchy thing that you can't really get a hold of. Some people will say that I am going to build this edifice, but yet you can't get the permit. You don't see that until you go and apply for the permit. So I think there would be a lot of confusion, a lot of—lack of aggressiveness for investors, or from companies who are willing to grow. They may take that business elsewhere, instead of taking it to Washington, or some other place because of the uncertainty.

Mr. NEWHOUSE. Okay.

Dr. RICE. Mr. Newhouse——

Mr. NEWHOUSE. Dr. Rice, yes?

Dr. RICE. I would like to add to the discussion, as there has been a lot of discussion this morning about the costs of the new rule. And I would like to—and there was that analogy that I brought up about making a diagnosis of pneumonia. And I want to set it clear for the record that, at this stage, when the EPA is setting the standard, costs are not supposed to factor into the decision of what a safe standard should be for public health. That should be based on the scientific evidence of health effects, and not the cost of implementation.

And one of the witnesses, Mr. Alford, had commented that he felt that setting the standard in the range of 60 to 70 would be called—would be going overboard. And I would like to raise a question of what—what part—which asthma admission is going overboard? Which child who ends up in the ICU with a respiratory infection that was triggered by a high ozone event is overboard? And I would like you to ask the parents of those children whether they would agree that that is going overboard.

Mr. ALFORD. Is that a question to me?

Mr. NEWHOUSE. Well, I have gone over my time, Mr. Chairman. Thank you very much.

Chairman SMITH. Okay. Mr. Alford, would you want to respond to that question?

Mr. ALFORD. Well, I don't accept—I refute a lot of the things that have been said here today. You have got ozone going down, you have got asthma going up. Something else is causing asthma. I don't—maybe it is just my stupid common sense thinking that.

Chairman SMITH. Okay.

Mr. ALFORD. But the—there—I am looking, I am trying to find a correlation. I am spending money trying to find a correlation on asthma as it relates to ozone, and so far, sir, and in a month I can go public with this thing, I don't see the correlation.

Mr. NEWHOUSE. Thank you, Mr. Alford. Thank you, Mr. Newhouse. We will go to the gentleman from Kentucky, Mr. Massie, for his questions.

Mr. MASSIE. Thank you, Mr. Chairman. This is not an issue that should be partisan. I mean, we all want clean air, and we all want a vibrant economy. And as evidence of the fact this is—this shouldn't be a partisan issue, and is not a partisan issue in Kentucky, I would like to submit for the record a letter from our Democrat governor to the President of the United States, and copied also the Administrator of the EPA.

Chairman SMITH. Without objection.

Mr. MASSIE. And I want to read from this letter from our Democrat governor to the President. "I am writing concerning the anticipated EPA's proposed rule relating to ground level ozone standard. I appreciate the great challenge that the EPA faces in setting health-based standards. As you are aware, protecting the health of Kentuckians is of critical importance to me. However, I must share with you the concern I have that the new ozone standard could create a hardship for many of our communities." And I will skip to this section, "This is of critical importance because if a lower standard is selected, counties in Kentucky that have never before experienced the ramifications of a non-attainment designation may be forced into that position."

He goes on to say, "My advisors recommend the ozone standard should remain unchanged for the time being. There are many environmental rules driving up costs in Kentucky that will negatively impact the economy. A new ozone standard does not have to contribute to these costs. Kentucky is a manufacturing state. For example, Kentuckians produce many of the vehicles, and much of the aluminum and steel manufactured in the U.S., and our manufacturers rely on low cost electricity to produce these products. I therefore ask you to retain the current ozone standard, which will continue to protect the health of our citizens without burdening our communities with costly non-attainment compliance programs. The growth of our economy is dependent on it."

You know, in Kentucky we found this interesting correlation, I am sure you are aware of it, Dr. Rice, that poverty corresponds—is associated with a lot of health problems, such as diabetes and other things. Do you agree with that?

Dr. RICE. I do.

Mr. MASSIE. So that is really what we are, you know, our number one health problem in Kentucky—in a lot of regions of Kentucky turns out to be the economy.

Mr. Heaston, can you tell me what the ramifications of non-attainment designation might be for some of our more rural areas that are trying to attract industry?

Mr. HEASTON. Well, I think the effects are that you are going to have more bureaucracy. You will have controls you will have to put into a structure. If it currently didn't have an air quality program, you are going to have to start from scratch, and start instituting controls, which immediately sets into play certain limits on which new sources can be sited, and then the existing sources are going to have to comply through prescriptive controls that are for that particular designation that you have.

Mr. MASSIE. So I notice that in many days of the year that Southern California basin is in non-attainment of the current standard. What would be the economic impacts of saying that tomorrow they have to attain 75 parts per billion?

Mr. HEASTON. Well, I mean, I can't speak for the South Coast Air Quality District, I can only speak for my own district, but what is going to end up happening is I will bump up. If I can't meet the standard by the assigned date, then I have to go into what they call a bump up provision, and that means I go into a more stricter controlled environment. So those sources that are already in my district would then have to suffer even lower limits when they do changes, or modifications, or if a new company comes in. So those aren't very pleasant things to have happen to you if you can't attain. There are some punitive effects. There is Section 185. Section 185 has the unpleasant presumption presuming that the stationary sources was the reason you didn't attain.

And when you didn't attain, it levies fines against the businesses that really weren't part of what was exacerbating the problem, or caused you not to attain. Because if they did the cuts that were prescribed into the Clean Air Act, they have done their part. But if we were still in non-attainment, then the burden of the fees and the penalty goes on them, and not the public.

Mr. MASSIE. So, Mr. Chairman, just to summarize, I want to say it should not be a partisan issue. We all want clean air. We all want healthy constituents. We all want a vibrant economy, but there is clearly a balance to strike here, and I hope we listen to our governors, Republican and Democrat, and I hope the EPA will do the same. Thank you, and I yield back.

Chairman SMITH. Thank you, Mr. Massie. The gentleman from Arkansas, Mr. Westerman, is recognized.

Mr. WESTERMAN. Thank you, Mr. Chairman, and I would request unanimous consent to submit a study from the Institute for Energy Research, and a letter from the American Forest and Paper Association.

Chairman SMITH. Okay. Without objection.

[The information appears in Appendix II]

Mr. WESTERMAN. So, as already discussed, there is evidence that suggests that the basis for the EPA's ozone rule, which attempts to link asthma to ozone as an outdoor air pollutant, is not necessarily on a good foundation. In fact, according to a study published in the "Journal of Allergy and Clinical Immunology", indoor air pollution that is correlated to poverty creates a higher risk for asthma than outdoor air pollution.

We all know that forests and forest products are very environmentally friendly, and are critical for clean air. We understand the importance of trees in the carbon cycle. We know that trees, through photosynthesis, pull down carbon. When those trees are processed into two by four's, and plywood, and oriented strand board, and put into houses, or put into furniture, that carbon is sequestered where those trees were cut down. New trees grow up. When they are younger, they grow faster, they pull more carbon out of the atmosphere, and they are very important to clean air. The wood we see in this room is sequestering carbon, and it has been for some time.

All while sequestering carbon and cleaning the air, the forest products industry employs nearly 900,000 men and women in 47 states, and is among the top ten manufacturing sector employs. This generates wealth, which lifts people out of poverty, which is good for their quality of life, including their health. Through existing rules, such as boiler maximum available control technologies, the forest products and paper industries are already improving air quality. VOC emissions are going down, and NOCs are down by over 25 percent from 2000 to 2012.

The ozone rule will drive up costs in the forestry and forest products industry, which will result in closed facilities, which will mean less jobs, less carbon sequestration, more poverty, and more asthma. So, Ms. Rice, I have a question for you. Do EPA's health effects include the negative health effects of employment cost?

Dr. RICE. Are you asking me whether the effects on employment were incorporated in the EPA cost analysis?

Mr. WESTERMAN. Right.

Dr. RICE. I don't believe that the employment related to the regulation was taken into account.

Mr. WESTERMAN. Even though there are studies that show that——

Dr. RICE. Um-hum.

Mr. WESTERMAN. —poverty is related to indoor air pollution, which is correlated with asthma? You have totally disregarded the effect of employment, and jobs, and poverty on your cost analysis?

Dr. RICE. So I haven't done any cost analysis, just to be clear. I am a physician who does——

Mr. WESTERMAN. Well, EPA.

Dr. RICE. —research on air quality. And the standard, as I have said many times, should be set based on a level that is considered to protect public health, with an adequate margin of safety. The evidence that ozone makes asthma worse is very well established. There are hundreds and hundreds of studies to show that ozone makes asthma worse.

What you are referring to is a very well designed study examining asthma prevalence, so how common asthma is in different parts of the country, and found evidence that poverty is associated with asthma prevalence. That is—that study did not look at ozone.

Mr. WESTERMAN. What about in the case of the forest products industry, where you have a very green material that is good for the environment, yet these standards are going to hurt the industry, which will cost jobs, which will close down facilities, which means less trees will be utilized, which will mean less carbons being sequestered in the air, is becoming less clean?

Dr. RICE. We have been talking a lot about costs today, and I do agree with you that costs are important, and costs present challenges, and costs should be part of the implementation process, and the decision process on how to implement the standard. But I think the standard should be established based on the health consequences——

Mr. WESTERMAN. Well, if we take cost out of the equation, and just use the science of air quality, these regulations will negatively impact air quality because they will remove operations that ultimately add to the cleanness of the air.

Dr. RICE. Though I am a physician, and not an expert on the forest industry, I respectfully disagree with the prediction that these—that setting a lower standard will worsen air quality.

Mr. WESTERMAN. I am an engineer and a forester, and I disagree with you, and I can tell you that raising these standards will hurt this sector of the economy, which will, in essence, hurt the air quality overall. Thank you, Mr. Chairman.

Chairman SMITH. The gentleman's time has expired, and thank you, Mr. Westerman. The Ranking Member, Ms. Johnson, is recognized.

Ms. JOHNSON. Thank you very much, Mr. Chairman. I have a letter from Dr. Corinne Keet, the lead author of the study that was mentioned by my colleague. This letter clarifies the results of the study, and the misinterpretation by some that ozone—is not important for asthma. Dr. Keet outlines how the conclusions drawn in recent articles on her study are false. She states in the letter that her study found that poverty and race were major risk factors for asthma prevalence, and that living in urban areas was not a major risk factor, but that her study does not suggest that air pollution and ozone are not important for asthma.

She goes on to state that a link between ozone levels and respiratory health outcomes is supported by many studies that have been used—use a variety of methods. And I ask unanimous consent that this letter be included in the record.

Chairman SMITH. Without objection, the letter will be made a part of the record.

[The information appears in Appendix II]

Chairman SMITH. And the gentleman from Oklahoma, Mr. Lucas, is recognized.

Mr. LUCAS. Mr. Chairman, I ask by unanimous consent that a letter from Dale Moore, Executive Policy Director of the American Farm Bureau Federation, to Gina McCarthy, Administrator of the EPA, be submitted to the record with the insights that it provides on this very important subject matter.

Chairman SMITH. Without objection, so ordered.

[The information appears in Appendix II]

Chairman SMITH. We have no further Members to ask further questions. And I just want to thank the panel today. You all have just given excellent testimony. We appreciate your making the effort to be here today. We had a lot of good exchanges, picked up some new ideas as well, and we stand adjourned.

[Whereupon, at 12:13 p.m., the Committee was adjourned.]

Appendix I

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. Harry C. Alford

NBCC | National Black Chamber of Commerce®

4400 Jenifer St. NW Suite 331 | Washington, DC 20015
Office: 202-466-6888 | Fax: 202-466-4918
www.nationalbcc.org | info@nationalbcc.org

April 27, 2015

1. The President talks a lot about funding for road and bridges. Could EPA's stringent ozone proposal block needed infrastructure projects – even if the money is made available?

The EPA proposal will put the vast majority of locations out of attainment. Thus, no projects, regardless of funding, will be permitted. Our infrastructure will continue to go neglected at the cost of safety and quality of life for our communities throughout the nation.

2. What are the public health impacts of not being able to find a job? Does EPA account for these impacts in their stringent ozone proposal?

Quality care is eliminated when there is no consistent and/or sufficient income for members of families without jobs. Disease and serious ailments will exist and cause a shortening in a person's life span. The EPA has no consideration of this fact (lost jobs due to fewer projects and programs). This is worse than laissez-faire it is a total state of denial.

Harry C. Alford
President/CEO

Responses by Mr. Raymond Keating

SBE
COUNCIL
Small Business & Entrepreneurship Council

April 23, 2015

The Honorable Lamar Smith
Chairman
Committee on Science, Space, Technology
U.S. House of Representatives
2321 Rayburn House Office Building
Washington, D.C. 20515-6301

Dear Chairman Smith:

On behalf of the Small Business & Entrepreneurship Council (SBE Council) and its Center for Regulatory Solutions project, I again thank you for the opportunity to testify before the Committee on Science, Space, and Technology in the hearing entitled *Reality Check: The Impact and Achievability of EPA's Proposed Ozone Standards* on March 17, 2015.

Following are answers to the questions submitted for the record by members of the Committee that were sent in your letter dated April 13, 2015.

1. What happens to permitting for new and expanding businesses throughout the country when ozone standards are set close to background levels?

Background ozone can be transported into a local airshed from distant sources, as well as ozone that occurs naturally. Scientists now understand that a range of industrial and other human activities throughout the world contribute to ozone concentrations in the U.S. In an April 2011 report, EPA scientists noted that:

> A growing body of observational and modeling studies suggests that the international anthropogenic [man-made] contribution to U.S. background ozone levels is substantial and is expected to rise in the future as rapid economic development continues around the world. Of particular concern is rising Asian emissions of nitrogen oxides (NOx), which can influence U.S. ozone concentrations in the near-term, and methane, which affects background ozone concentrations globally over decadal time scales.
>
> In particular, [a 2010 Report by the Task Force on Hemispheric Transport of Air Pollution] estimated that the contribution of NOx, non- methane VOC, and CO emissions in Europe, South Asia, and East Asia to North American ozone concentrations at relatively unpolluted sites is 32% of the contribution of emissions from all four regions (including North America) combined. That

> contribution is projected to rise to 49% in a conservative emissions growth scenario and to 52% in a scenario of aggressive global economic development.

As ozone concentrations in some areas decline and approach background levels, the range of policy options available to states to comply with EPA's more stringent ozone standards becomes more difficult, and for businesses and consumers, more costly.

As noted in my testimony, it was explained in an initial comprehensive economic study from NERA published in July 2014 ("Assessing Economic Impacts of a Stricter National Ambient Air Quality Standard for Ozone") that the problems that come with nonattainment are considerable: "Unlike regulations that target specific sectors, an ozone standard would directly affect virtually every sector of the economy, because ozone precursors (oxides of nitrogen, or NOX, and many types of volatile organic compounds, or VOCs) are emitted by a wide range of stationary, mobile, and area sources. Moreover, a tightened standard might result in other effects, notably potential constraints on domestic natural gas and crude oil development activity if nonattainment regions introduce permitting barriers or require emissions offsets to develop new wells and processing facilities."

The July 2014 report also explained what "non-attainment" means in practical terms, that is, new businesses must obtain air permits to operate. As NERA stated: "Finally, being in nonattainment of a NAAQS triggers more regulatory burdens than just reducing emissions to achieve attainment. A number of regulatory programs are also imposed on nonattainment areas. Significant among these is a requirement that any economic entity that wishes to obtain a permit to establish a new facility that will emit the pollutant(s) of concern in a nonattainment area must first find an offsetting reduction of those same emissions from another facility that is exiting the area, or has voluntarily reduced its own emissions below its permitted level. Markets for these 'offsets' often develop, but offsets can be exceedingly costly or difficult to find if there are few existing emitting facilities in the area to create a supply. A tightened ozone standard has the potential to cause nonattainment areas to expand into relatively rural areas, where there are few or no existing manufacturing facilities to generate a supply of offsets. If nonattainment expands into rural areas that are active in U.S. oil and gas extraction, a shortage of offsets may translate into a significant barrier to obtaining permits for the new wells and pipelines needed to expand (or even maintain) our domestic oil and gas production levels."

As offsets grow more costly, it becomes harder for local areas to attract new businesses, or expand existing businesses. As the American Forest and Paper Association has explained, "The inability to permit a project hurts the competitiveness of the facility, harms product development and innovation, and can thwart environmentally beneficial projects. Local communities will miss out on new jobs and economic growth while industry sectors face the risk of becoming uncompetitive."

Consider the case of Baton Rouge, Louisiana. Baton Rouge has already seen several major industrial projects dry up as the rule looms over the local economy. As Baton Rouge Area Chamber (BRAC) explained:

> Since the EPA first proposed lowering the ozone standard in December, the Baton Rouge Area has seen four major industrial projects totaling 2,000 direct and indirect jobs, and more than $7 billion in capital investment, either put on hold or redirected elsewhere. These losses are in direct correlation with the uncertainty created by the newly proposed ozone standards rule. The direct impact on the Baton Rouge Area, in terms of new payroll created from the projects themselves, would have been over $86 million annually in wages for the local economy. Also, because these projects included foreign direct investment projects, they also represented new investment from multi-national corporations into the country. **Federal regulations concerning NAAQS are having a direct, negative effect on competing U.S. goals for increasing foreign direct investment and exports.**

BRAC officials are quick to emphasize that the ozone rule has not even been finalized yet. Once non-attainment becomes a reality, the consequences are likely to be more severe:

> In the Baton Rouge Area case…, these consequences came about merely from the regulation being proposed. Imagine the losses if it is actually implemented, losses not only for Baton Rouge but for other top-performing metros across the country. The implication is that U.S. government policy toward ozone, as proposed, runs in direct contradiction to America's economic goals.

2. EPA Administrator Gina McCarthy wrote an op-ed saying that the Agency's air standards "attract new business, new investment, and new jobs." That might sound good politically, but is it correct economically?

As noted above and in my testimony, the answer, quite simply, is no. Consider also the American Chemistry Council summed up this issue well, citing Houston, Texas, as an example of why Gina McCarthy is wrong:

> The experience of Houston, Texas is illuminating. Despite billions spent on emission controls and a dramatic reduction in air pollutants, the area is in nonattainment with the current ozone standard of 75 parts per billion. As a result, there are strict regulatory permitting requirements for building or modifying factories and other facilities. Companies wanting to build or expand must pay for emission offsets before they can secure a preconstruction permit. These offsets are scarce, and expensive – over $175,000/ton of VOc/NOx. Even facilities that are not expanding can feel the pain of operating in a nonattainment area. When a standard is lowered, states often have to implement new regulations or more stringent ones. For example, facilities in the Houston area with combustion units, such as boilers and ethylene crackers, must install burners that emit even lower NOx emissions. The point is that it is not only new investment that is at risk. Many states will be unable to meet EPA's proposed lower NAAQS. Most likely, facilities in these locations will expand only if they shut down operations elsewhere or are able to come up with the significant additional investment needed to buy pricey offsets.

Also, ACC has noted that, "It is very likely that facilities would expand *only* if they shut down operations elsewhere, or they came up with the significant additional investment required to buy increasingly expensive offsets. Economic growth, new jobs, and a sustainable competitive advantage for U.S. manufacturing are at risk from a lower ozone standard."

As I concluded in my testimony, small businesses in non-attainment areas will have a difficult time starting up, expanding and competing for "offsets," as those offsets will be expensive, or perhaps not exist when needed. Compliance will be complex and costly. Economic opportunity and job creation will suffer. The expense and red tape will be a barrier to new startups and business formation. These regulations would hamper local efforts to spur new business creation, and could, in effect, serve as a cap on entrepreneurship and small business growth.

3. Could unnecessarily stringent regulations like EPA's ozone proposal push businesses off shore to countries with lower environmental protections? How does that help the environment?

Consider recent testimony by the Industrial Energy Consumers of America on climate change regulation (http://docs.house.gov/meetings/IF/IF03/20150414/103312/HHRG-114-IF03-Wstate-CicioP-20150414.pdf). As IECA explained, "Offshore competitors, who import product into the U.S., must be held to the same environmental standards as domestic manufacturers, or GHG leakage of jobs and emissions will occur, which accomplishes nothing environmentally."

When it comes to the EPA's Clean Power Plan: "It is clear that the CPP as proposed will dramatically increase the cost of power and natural gas, while providing our offshore competitors an economic advantage, potentially creating GHG emission leakage, and with a harmful effect on jobs, the economy, and the environment."

IECA also noted:

> U.S. and E.U. industrial sector GHG emissions have declined, China's industrial GHG emissions have substantially increased. While no U.S. corporation would want to substitute the quality of air in the U.S. for that of China, these numbers are a clear reminder that there are clear winners and losers, and consequences for higher cumulative costs heaped upon the U.S. manufacturing sector.
>
> While the manufacturing sector, especially the EITE industries, have benefited from the low cost of natural gas, the cost of regulation continues to weigh heavily on investment, job creation, and global competitiveness. According to the National Association of Manufacturers (NAM) 2014 study "The Cost of Federal Regulations to the U.S. Economy, Manufacturing and Small Business," the total cost of federal regulations in 2012 was $2.028 trillion (in 2014 dollars). Of course, not all regulation is bad regulation. Nonetheless, many of these regulatory costs are costs that our offshore competitors do not have.

One can easily imagine that a harsh ozone standard would have the same effect.

4. EPA's cost analysis claims that the costs of implementing its proposed ozone standard have gone down by $29 billion in the last four years. Is this an economically sound assumption?

It is well worth considering another point highlighted in my testimony from the NERA Economic Consulting comprehensive study, which was updated in February 2015 ("Economic Impacts of a 65 ppb National Ambient Air Quality Standard for Ozone"), regarding these EPA ozone regulations:

> As opposed to the EPA's essential guesswork on costs, the NERA study attempts to get at the real potential costs based on the realities of the marketplace. As noted, "As in the July 2014 analysis, emission reductions from 'known' controls were not sufficient to achieve attainment, in this case with a 65 ppb ozone standard. EPA has filled the gap with a rough estimate of costs of 'unknown' controls, i.e., controls for which no cost information was developed. In contrast to the two cost estimation methodologies presented in its 2008 and 2010 RIAs, this time EPA used a single simplistic assumption that annualized control costs for these 'unknown' controls would be equal to $15,000 per ton, regardless of the state, the sector, or the amount of emission reduction required. This estimate was not based upon any evidence-based analyses of the nature of the emissions that remain after 'known' controls are in place, or of the costs of potential additional controls for these sources. Our compliance cost estimates are based upon a synthesis of EPA estimates of emission reduction, our modifications of EPA's assumptions regarding baseline reductions, EPA's estimates of the costs of 'known' controls, and our more detailed estimates of the costs of 'unknown' controls. As in our July 2014 report, our 'unknown' cost estimates are more evidence-based than EPA's, as we use detailed information on the types of sources that account for the remaining emissions (EGUs, other point sources, on-road sources, off-road mobile sources, and area sources) as well as estimates of the potential costs of reducing emissions by scrapping existing emission sources prematurely."
>
> And later in the report: "We estimate that the potential costs of achieving a 65 ppb ozone standard could have a present value of almost $1.1 trillion as of 2014 (based upon costs incurred from 2017 through 2040), not including any costs for forcing a massive cutback in generation from coal-fired EGUs to reduce NOX emissions from the power sector (whose costs are endogenously determined in the economic impact model)... As a rough point of comparison, we estimate that EPA's annualized cost estimate implies a present value of about $167 billion. The primary difference in our methodologies is the extrapolation method used to estimate the cost of 'unknown' controls; we attempted to assess the kinds of controls that would be required after "known" controls and based our method on the estimated costs per ton of one such control (vehicle scrappage), whereas EPA relied on an arbitrary constant value."

5. Do you think EPA's cost estimates for its stringent ozone proposal would be closer to its 2010 estimates—costs which Cass Sunstein warned would be "especially harmful to the poor"—if EPA didn't change their methodology and cap costs for unknown controls?

Absolutely. In its 2010 regulatory impact analysis of its ozone proposal, EPA found that lowering the standard within the range of 60 to 70 ppb could cost as much as $90 billion annually. EPA's updated RIA, however, shows much lower costs—and costs that are far below those found by NERA in its analysis. NERA estimates costs at $140 billion on average annually between 2017 and 2040.

The issue gets to what EPA calls "unknown controls," or controls that are not available, and therefore EPA has no idea of their cost to install and operate. Interestingly, in February 2015 testimony before the House Government Reform Committee, NERA's Ann Smith noted that under a 65 ppb standard, "approximately half of the needed reductions in emissions are left unidentified by USEPA. It is a matter of intuition (and economic reality) that reductions that cannot be identified in a cost analysis probably become increasingly more costly than those that can more readily be identified." Smith continued:

> In its 2008 and 2010 RIAs, USEPA made efforts to roughly approximate this increasing cost per ton; in the current RIA, however, USEPA has simply assumed that all of those unknown control measures will be available at an average of only $15,000 per ton – no matter how deeply one has to cut back on total baseline emissions. NERA staff have performed calculation replicating USEPA's cost estimates and we have found that if one simply replaces the current RIA's flat $15,000 per ton for the "unknown" reductions with the same upward-sloping cost per ton assumption that USEPA used in its two prior ozone RIAs, *the estimated costs for the alternative rules today will be essentially the same as they were before.*

Again, as I noted in my testimony, the proposed ozone rule not only has the potential to be the "most expensive regulation" ever enacted by the federal government in U.S. history, it will be one that severely impinges on entrepreneurship and economic freedom.

I appreciate this opportunity, and please let us know how SBE Council can be of further assistance.

Sincerely,

Raymond J. Keating
Chief Economist
Small Business & Entrepreneurship Council

Responses by Dr. Mary B. Rice

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Suite 300
Washington, D.C. 20036
P. (202) 296 - 9770
F. (202) 296 - 9776
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April 27, 2015

The Honorable Lamar Smith
Chairman
Science, Space and Technology Committee
U.S. House of Representatives
Washington, DC 20515

The Honorable Eddie Bernice Johnson
Ranking Member
Science, Space and Technology Committee
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Smith and Ranking Member Johnson:

Thank you for the opportunity to respond to follow up questions from the House Science Space and Technology Committee hearing on the human health risks of ozone exposure held on March 17, 2105. As a member of the American Thoracic Society, I appreciate the opportunity to share with committee the scientific facts documenting the severe adverse health effects caused by exposure to ozone.

I also appreciated the opportunity to provide further information in response to your follow up questions from the hearing. Please find the below responses:

1. **Can you please explain the difference between the prevalence of asthma and the incidence of asthma attacks and the role air pollution plays in both?**

Asthma prevalence refers to how common asthma is, or specifically, how many people as a proportion of the population have been diagnosed with asthma. In the U.S., the prevalence of asthma has been rising in the past 30 years: from 3.1% in 1980 to 5.5% in 1996 and 8.4% in 2010 [1]. The reason for the rising prevalence of asthma is the subject of intense scientific investigation, and so far there has been no simple explanation for why asthma prevalence is rising. People who live in the U.S. but were born elsewhere have a lower risk of asthma than people who were born and raised in the U.S., which suggests that there are early life exposures in the American environment that increase the risk of developing asthma [2],[3].

Air pollution has been proposed as an exposure that may increase the risk of developing asthma. However, research findings have been inconsistent on this issue, with most studies finding that air pollution slightly increases the risk of developing asthma, and others not [4],[5].

Most likely, there are a whole host of factors that explain why asthma prevalence is on the rise in the U.S., including higher rates of doctor diagnoses because of a higher awareness of asthma as a childhood disease, longer and more potent pollen seasons, obesity, nutrition, breastfeeding, hand hygiene, and changes in the mix of a number of environmental exposures, including pollutants, viruses, and fungi [6].

The incidence of asthma attacks refers to the risk of having an asthma attack among people who already have asthma. Studies have consistently found that exposure to air pollution, and ozone in particular, increases the risk of having an asthma attack among people who have asthma[7–13]. From 2001 to 2010, while ozone levels generally declined in the U.S., the incidence of asthma attacks among children and adults with asthma has also declined [1]. **The fact that asthma prevalence is on the rise means that more and more people in America are at risk of an asthma attack during high ozone days.**

2. **During the hearing, some members seemed to suggest that there is disagreement within the scientific community on the health effects of ozone. What evidence can you provide the Committee that would demonstrate a consensus opinion among major professional medical groups on the health effects of ozone?**

That ozone exposure harms human health is a well-established scientific conclusion. Prior reviews of ozone by the independent Clean Air Scientific Advisory Committee have consistently identified multiple health effects, including, but not limited to: reduced lung function among healthy adults and those with asthma; hospitalization for asthma, respiratory infection and chronic obstructive pulmonary disease; and increased risk of premature mortality [14–17] These associations have been demonstrated repeatedly in a multitude of studies over many decades. Other scientific panels and major professional medical groups have identified these health effects of ozone in consensus statements. They include the World Health Organization [18], the National Academies of Science[19], the American Medical Association, the American Thoracic Society, the American Lung Association, the Academy of Pediatrics, the American Public Health Association, and many others[20], [21]. Each of these organizations and professional groups has independently examined the scientific evidence and reached a consensus that ozone is harmful to human health.

Again, the American Thoracic Society appreciates the opportunity to testify before the committee. Please let me know if you have questions or need additional information.

Sincerely,

Mary B Rice, M.D.
Member, American Thoracic Society Environmental Health Policy Committee

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Responses by Dr. Allen S. Lefohn

Allen S. Lefohn, Ph.D.
A.S.L. & Associates
302 North Last Chance Gulch
Suite 410
Helena, Montana 59601
asl-associates.com

Responses to Questions for Dr. Allen S. Lefohn

April 17, 2015

Preface

Background is a significant contributor to observed ozone concentrations throughout the U.S. and its contribution increases as lower standard levels are considered. As such, background levels will impact the ability to attain the standard, the amount of ozone precursor emissions that must be controlled to attain the standard, and the margin of safety that can be imposed to assure the standard provides adequate safety. Ignoring background will not prevent it from making itself known.

In my response to the first question, I note that for those monitoring sites, which are currently heavily influenced by anthropogenic (i.e., manmade) ozone precursor emissions, they experience their 4th highest 8-hour concentration during the summer. However, if emissions were reduced across the U.S. to achieve alternative lower ozone standards, modeling indicates that there will be a tendency for the 4th highest 8-hour concentration to occur not just during the summer, when traditionally, anthropogenic ozone formation is high, but in some locations, to occur during the spring when the main contributors to ozone are background sources. The locations affected by the springtime shift can appear anywhere across the entire U.S. I also note that with more stringent proposed standards, background will become an even more important contributor to exceedances of the standard all across the U.S. than it is under the current standard.

For the second response, I point out while other controlled human exposure and epidemiological studies have been published since the last rulemaking, for the current rulemaking the Administrator has focused on the controlled human exposure study performed by Schelegle et al. (2009) for setting the primary standard. She acknowledges that effects reported in controlled human exposure studies are due solely to ozone exposures while in contrast, epidemiological studies incorporate confounding factors and uncertainties about exposure that may obscure the cause-effect relationship. In addition, the Administrator acknowledges that higher ozone concentrations have a proportionately higher impact than lower concentrations and therefore, are an important consideration in determining ozone's health impact. Extremely important work by Hazucha et al. (1992) and Adams (2003; 2006a, 2006b) form the scientific foundation for the focus on higher ozone concentrations. Lefohn, Hazucha, Shadwick, and Adams (Lefohn et al., 2010a) conclude that higher ozone concentrations are important in FEV_1 responses and that the effect is cumulative based on exposure. The Lefohn et al. (2010a) findings are similar to the vegetation effects conclusions reached by the EPA (2013). The importance of the higher concentrations and the cumulative nature of the effects is the basis for the EPA using the W126 exposure index (Lefohn and Runeckles, 1987; Lefohn et al., 1988) for assessing vegetation effects.

In the third response, I note that estimated health risks provide information to inform the Administrator on the margin of safety. Background contributes to, and therefore confounds health risk estimates. Background will be one of several factors influencing the margin of safety determination.

For the fourth response, I point out that the threshold estimate from the Jerrett et al. (2009) study cannot be used as evidence to support an 8-hour 60 ppb standard because the ozone averaging time is quite different between Jerrett et al. and the NAAQS. The form of the ozone NAAQS is the 3-year average of the annual 4th highest daily maximum 8-hour average concentration. Jerrett et al. (2009) appeared to use a long-term (i.e., 24 years) average ozone concentration that is not related to the current form of the ozone standard.

Response to Specific Questions

1. **In your testimony and response to questions, you mentioned that there is a shift in the peak ozone downward and a shift in the lower ozone upward. In fact you used a slinky to demonstrate how the ozone distribution is shrinking to the mid-range and that background makes up a large percentage of this mid-range. Besides the shift of the ozone to the mid-range are there other examples, such as seasonal shifts in ozone occurrences that illustrates the importance of background ozone on potential violations of the proposed ozone standards?**

Currently, at most ozone monitoring sites heavily influenced by anthropogenic emissions, the annual 4th highest (H4 MDA8) 8-hour concentration occurs during the summer. However, if emissions were reduced across the U.S. to achieve alternative lower ozone standards, modeling indicates that there will be a tendency for the annual 4th highest (H4 MDA8) 8-hour concentration to also occur during the spring. This observation is confirmation that background ozone will increase its influence when exceedanees of the lower standards occur.

One of the key aspects of background ozone is that it currently makes up a large percentage of the observed ozone measured in the West and Intermountain West. In addition, background ozone currently makes important contributions to the observed ozone levels measured across the U.S. As I indicated in my testimony, as emissions are reduced, background ozone will increase in importance in its contribution to observed ozone across the U.S. because it will not be titrated by anthropogenic emissions as much as experienced under current conditions. When emissions are reduced to attempt to attain lower ozone standards, there is evidence that background ozone will increase its contribution to violations across the entire U.S.

The EPA (2014a) reports that background ozone currently makes up a relatively large percentage (e.g., 70 to greater than 80%) of the total seasonal mean ozone at locations within the intermountain western U.S. and along the northern and southern U.S. border during the April-October period. For many low-elevation sites in the West, as well as the remainder of the U.S., the contribution of background ranges from 50% to greater than 80% (EPA, 2014a; Dolwick et al., 2015).

EPA (Federal Register, 2014 – page 75383) agrees that there is no question that as the levels of alternative prospective standards are lowered, background will represent increasingly larger percentages of total ozone levels and may subsequently complicate efforts to attain these standards. If lower standard levels were promulgated, background concentrations will increase and exceedances will become more common. Exceedances of lower proposed standards at times may be associated with natural enhancements to observed surface ozone concentration (i.e., episodes driven by stratospheric intrusions and wildfires), while at other times exceedances may be associated with natural enhancements combining with international transport and other local/regional sources, such as biogenic, lightning and anthropogenic emissions. For the high-elevation sites in the western U.S., many exceedances will be associated with natural enhancements. As emissions are reduced, lower-elevation sites throughout the remainder of the U.S., which currently experience natural stratospheric-contributed enhancements combined with other sources (Lefohn et al., 2014), will experience exceedances associated with increasing background contributions.

The importance of background ozone has been noted in Appendix 4D of the Health Risk and Exposure Assessment (EPA, 2014b, c). EPA (2014c) illustrates monthly boxplots of hourly ozone concentrations at monitor locations in each of 15 urban areas for observed air quality in 2006-2008 and 2008-2010, for air quality predictions meeting the existing 75 ppb standard, and for air quality predictions meeting the alternative standard of 65 ppb (Figures 4D-28 through Figure 4D-42). From these figures, EPA notes that when emission reductions occur, on days when the daily maximum 8-hour average concentrations (MDA8) are in the midrange levels, there is a shift of the higher mid-range ozone concentrations from the summer toward the spring months. Currently in most cities, the highest interquartile (i.e., 25th to 75th percentiles) ozone concentrations occur during the summer months (i.e., June-August). However, in the 75 and 65 ppb scenarios, the highest interquartile ozone concentrations in many areas shift toward the spring months (i.e., April-May). EPA (2014c) notes that this shifting pattern is associated with a higher contribution from non-U.S. anthropogenic sources (i.e., background). In other words, as noted by the EPA, many of these non-U.S. anthropogenic sources, such as stratospheric intrusions and international transport, peak during spring months and therefore, background ozone, as acknowledged by the EPA (2013), will grow in importance as emissions are reduced to meet alternative standard levels. The figures in the HREA (EPA, 2014c) most clearly show effects on midrange and inter-quartile hourly ozone concentrations, and EPA tends to focus the discussion on those ranges. However, as demonstrated below, the very same effect occurs for the highest ranges in daily maximum 8-hour (MDA8) ozone, including the annual 4th high (H4 MDA8) upon which the ozone standard is based.

During 2014, ENVIRON, an environmental consulting firm, conducted photochemical modeling of the entire U.S. for the years 2011 and 2018, using the EPA's modeling platform. The analysis used the same model version, meteorology, and other inputs as EPA's analysis supporting the Agency's Risk and Exposure Analysis (EPA, 2014b). Specifically, version 6.10 of the Comprehensive Air Quality Model with extensions (CAMx) was employed using 2011 meteorology, initial/boundary conditions and other ancillary inputs that comprise the EPA's

2011 modeling platform. Additionally, the 2011 and 2018 modeling platform emissions (version "ED") were used to determine 2018 emission reduction necessary to achieve the 60 and 70 ppb alternative ozone standards throughout the U.S. These datasets were obtained in early 2014 from the Lake Michigan Air Director's Consortium (LADCo), acting as EPA's modeling data warehouse. Further details of the modeling methodology are described in Appendix A at the end of my response to questions.

Figures 1-3 on the next pages display the spatial variation in months when simulated annual 4th high (H4 MDA8) occurs in each model grid cell for the 2011 base case and two 2018 cases meeting 70 and 60 ppb standards. Shades of green in the figures represent the occurrence of the annual 4th high (H4MDA8) concentrations during the spring months. The figures illustrate that as emissions are reduced, the amount of green (i.e., March-May months) in Figures 2 and 3 increases. ***This indicates that as emissions are reduced across the U.S. to meet the two 2018 cases for alternative standards (Figures 2 and 3), simulated annual 4th highest (H4 MDA8) concentrations tend to shift from predominantly summer month occurrences (i.e., June, July, and August) over most of the U.S. to a wider range of months, particularly during the spring months.***

Thus, if emissions were reduced across the U.S. to achieve alternative lower ozone standards, modeling indicates that there will be a tendency for the 4th highest 8-hour concentration to occur not just during the summer when traditionally, anthropogenic ozone formation is high, but in some locations, to shift to the spring when the main contributors to ozone are background sources. The occurrence of springtime 4th highest 8-hour concentrations is already observed at some monitoring sites in the Intermountain West. Background ozone will grow in importance across the U.S. as emissions are reduced. At times, violations of proposed lower standards will occur during the spring, not just in the western U.S., but across the entire country.

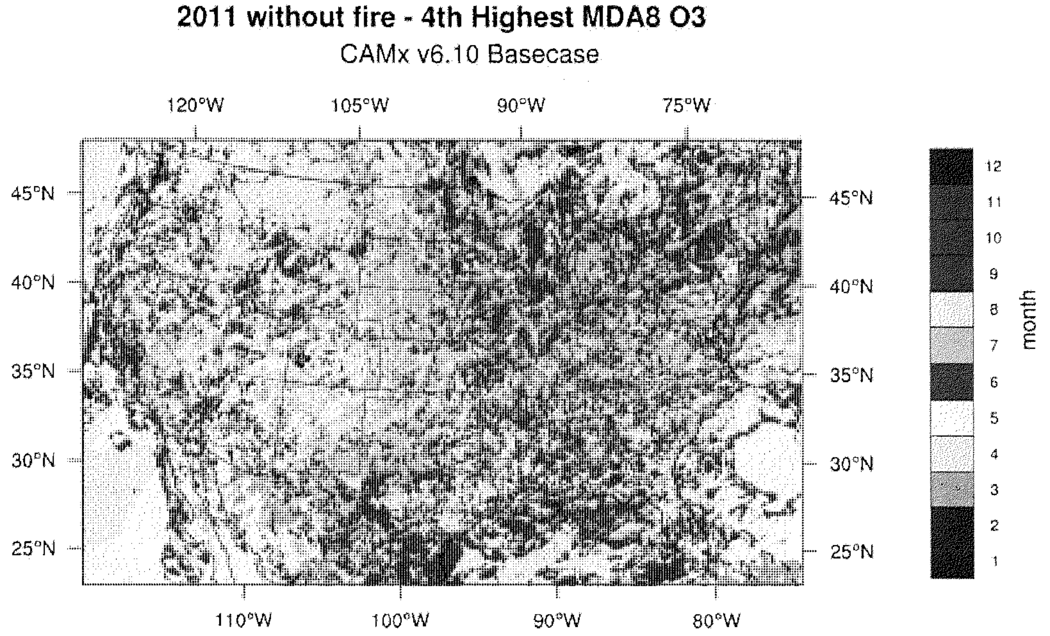


Figure 1. Months when annual H4 MDA8 occurs in each model grid cell for the 2011 base case.

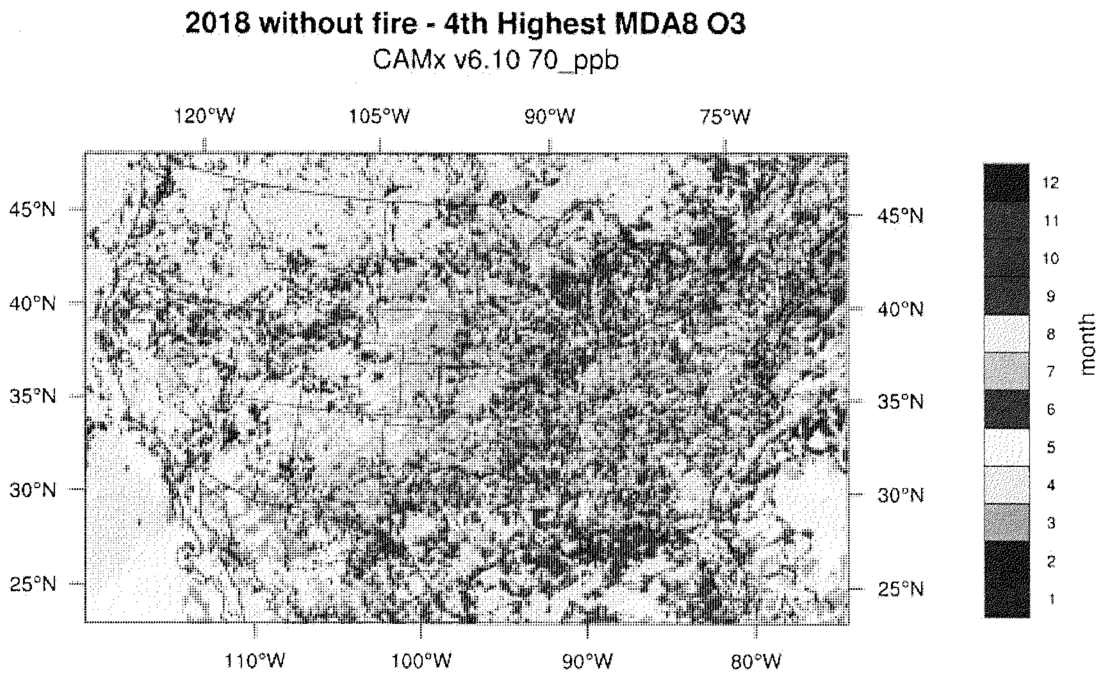


Figure 2. Months when annual H4 MDA8 occurs in each model grid cell for the 2018 case meeting a 70 ppb standard. Note the additional green areas compared to Figure 1.

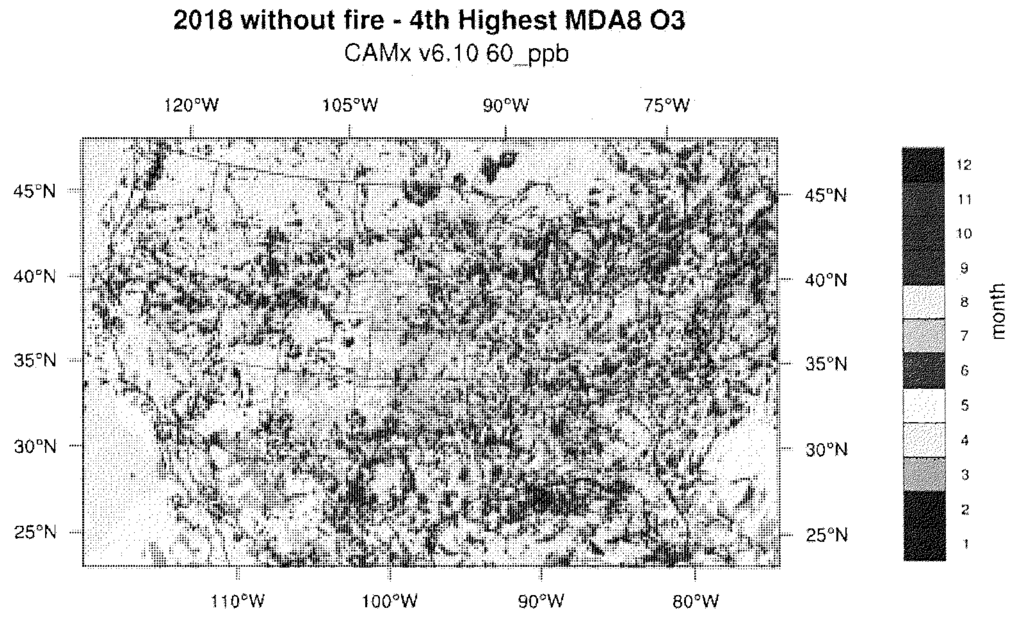


Figure 3. Months when annual H4 MDA8 occurs in each model grid cell for the 2018 case meeting a 60 ppb standard. Note the additional green areas compared to Figures 1 and 2.

2. **In your response to questions, you mentioned that there was really only one new study that EPA was using to propose a lower standard and that the study only had 31 participants. Dr. Rice testified that there were 100's of studies that indicated a need to lower the standard. Could you please explain why the Administrator appears to be focusing on this one study?**

A controlled human exposure experiment published after the last ozone rulemaking in 2008 appears to be the key study that the Administrator has focused on for the selection of the primary ozone standard. While other controlled human exposure and epidemiological studies were also published during this time, the Administrator has decided to focus on the Schelegle et al. (2009) study for setting the primary standard. However, before discussing why the single controlled human exposure experiment outweighs other studies, I would like to describe the history on the science that provides the context for why, among all the studies in the published literature, this single experiment stands out.

With respect to vegetation, it has long been recognized that higher ozone concentrations are an important factor when examining exposures affecting plant injury (Heck et al., 1966). In December 1981, at an informal discussion at the U.S. EPA research laboratory in Corvallis, Oregon, I brought up the question on the relative importance of the higher ozone concentrations versus mid- and lower-level hourly average values for assessing plant damage resulting in economic impact. At that meeting, EPA and I concluded that if the higher hourly average ozone concentrations had a greater effect on vegetation damage than the mid- and lower-level values, then *long-term average concentrations would be an inappropriate index* for assessing vegetation effects since the highest hourly average concentrations would be averaged out and no longer identifiable as the reason for the biological effect.

Soon after the Corvallis discussion, Lefohn and Benedict (1982) hypothesized that the higher hourly average concentrations should be provided greater weight than the mid- and low-level values when assessing crop growth reduction. In 1983, Musselman et al. (1983) provided experimental evidence supporting this hypothesis. In 1985, Hogsett et al. (1985), researchers at the EPA Corvallis Laboratory, applying exposure regimes designed by me, provided additional evidence for the importance of the higher hourly average ozone concentrations in affecting vegetation.

Following up on the Lefohn and Benedict (1982) hypothesis and the results reported by Musselman et al. (1983) and Hogsett et al. (1985), I proposed and developed the W126 ozone exposure index for predicting vegetation effects. The mathematical approach was described in Lefohn and Runeckles (1987) and the description of the W126 exposure index was presented in Lefohn et al. (1988). The W126 index is a weighted cumulative exposure index that provides greater weight to the higher hourly average ozone concentrations rather than the mid- and lower-level values. In addition, the W126 index does not impose an artificial threshold and is not an "average" of several values collected over the course of a short- or long-term time period. The W126 weighting scheme, as noted by the EPA (2013), is supported by research results performed under ***controlled*** conditions, as well as under ***uncontrolled*** exposure conditions, such as observed in the San Bernardino National Forest in the Los Angeles area. At the San Bernardino site, reductions in ozone exposures between 1980 and 2000 were related to improvements in tree conditions. The midrange hourly average ozone concentrations were little changed over this period. EPA (2013) suggested it was the reduction in the higher hourly average ozone concentrations that was responsible for the improvement in tree health.

EPA (2013) has concluded, based on a review of the literature, that (1) ozone effects in plants are cumulative; (2) higher ozone concentrations appear to be more important than lower concentrations in eliciting a response; (3) plant sensitivity to ozone varies with time of day and plant development stage; and (4) quantifying exposure with indices that accumulate the ozone hourly concentrations and preferentially weight the higher concentrations improves the predictive power of exposure/response models for growth and yield, over using indices based on mean and other exposure indices. Based on the peer-reviewed literature and its own research studies, the Administrator identified the W126 cumulative exposure metric as the most appropriate to use to evaluate both the adequacy of the current secondary standard and the appropriateness of any potential revisions (Federal Register, 2014 – page 75314).

Both vegetation effects research results and peer-reviewed papers describing controlled laboratory exposures of human volunteers indicate that higher ozone hourly average concentrations elicit a greater effect on hour-by-hour physiologic response than lower hourly average values. Similar to the Musselman et al. (1983) experiment that illustrated the importance of the higher concentrations for vegetation effects, Hazucha et al. (1992) showed that higher ozone concentrations were important for assessing FEV_1 lung function responses. In commenting on important controlled human exposure studies published in the literature, Hazucha and Lefohn (2007) emphasized that the results reported first by Hazucha et al. (1992), followed by Adams (2003; 2006a, 2006b), indicate that higher hourly average concentrations elicit a greater effect than the lower hourly average values. Lefohn, Hazucha, Shadwick, and Adams (Lefohn et al., 2010a) reanalyzed data from five controlled human exposure study experiments as reported by Hazucha et al. (1992), Adams (2003, 2006a, 2006b), and Schelegle et al. (2009). Lefohn et al. (2010a) were able to develop a cumulative concentration weighted ozone exposure index for human exposure (W90). Similar but not identical to the W126 index, the W90 index provides a quantitative way to give greater weight to the higher concentrations over the mid- and low-range values without having to apply an artificial threshold.

Having described the importance of the higher ozone concentrations in eliciting adverse effects for vegetation and human health, I can return to Dr. Rice's statement that there are 100s of studies that indicated the ozone standard should be lowered. Many of the studies she referred to in her testimony were associated with morbidity and mortality epidemiological studies. Some of these studies used long-term average concentrations, which may have resulted in misclassifying the ozone concentration hypothesized to be responsible for any health effect observed in the respective studies. Some of the other studies she undoubtedly had in mind were associated with controlled human exposure experiments, many of which the Administrator did not find to be key in her deliberations. Each of these study types is discussed briefly below.

The EPA Administrator acknowledged, when evaluating the epidemiological and controlled human exposure study results, that the higher ozone concentrations were an important consideration (Federal Register (2014 – page 75308). She then (Federal Register, 2014 – page 75288) agreed with the conclusions of the Agency's Policy Assessment Report (EPA, 2014a) that controlled human exposure studies provided the most certain evidence indicating the occurrence of health effects in humans following exposures to specific ozone concentrations. Specifically, she recognized that the effects reported in controlled human exposure studies were due solely to ozone exposures. In contrast, epidemiological studies incorporate confounding factors that may have obscured the cause-effect relationship. New controlled human exposure studies published since the 2008 rulemaking, which might provide findings to change the current standard, are Kim (2011) and Schelegle (2009).

The Administrator noted that controlled human exposure studies report the combination of lung function decrements and respiratory symptoms in healthy adults engaged in intermittent, moderate exertion following 6.6 hour exposures to concentrations as low as 72 ppb (based on Schelegle et al., 2009), and lung function decrements and pulmonary inflammation following exposures to ozone concentrations as low as 60 ppb (based on Kim et al., 2011) (Federal Register, 2014 – page 75288). However, the Administrator also notes that a level of 60 ppb is below the lowest concentration where the *combined* occurrence of respiratory symptoms and lung function decrements was observed (i.e., 72 ppb), a combination judged adverse by the American Thoracic Society according to the Administrator (Federal Register, 2014 – page 75302). The Administrator, noting the Kim et al. (2011) findings, has less confidence that health effects would occur below an ozone concentration of 72 ppb. Thus, only one controlled human exposure study (i.e., Schelegle et al., 2009) informed the Administrator's decision as to the level of the standard.

With respect to the epidemiological studies, the Administrator noted that the interpretation of studies' results was complicated by the presence of co-occurring pollutants or pollutant mixtures. In addition, she placed less weight on epidemiologic-based risk estimates because of key uncertainties about (1) which co-pollutants was responsible for any health effect observed, (2) the heterogeneity in effect estimates between locations, (3) the potential for exposure measurement errors, and (4) uncertainty in the interpretation of the shape of concentration-response functions for ozone concentrations in the lower portions of ambient distributions. As noted in the HREA (EPA, 2014b) with respect to the epidemiological studies, not differentially weighting the concentration-response functions at higher ozone concentrations greater than the mid- and low-level values resulted in small differences in the estimates of mortality and morbidity risks as a theoretical effort was made to impose more stringent standards. This occurs, as I indicated in my testimony on March 17, 2015, because as shown by EPA's modeling, as well as our trends results, as emissions are reduced to meet lower standards, the high end of the concentrations shifts downward (i.e., reducing mortality) but the low end of the distribution of concentrations shifts upward (i.e., increasing mortality), resulting in a small net benefit. As a consequence of the limitations in the epidemiology studies, the Administrator did not use these studies to set the proposed range for the level of the standard.

As described above, the Administrator (Federal Register, 2014 – page 75304) had little confidence that adverse effects would occur following exposures to ozone concentrations below 72 ppb. With the findings of the epidemiological studies being discounted because of numerous uncertainties affecting the interpretation of the results, the Administrator is relying on a single study to set the standard. She went on to conclude that a standard level as high as 70 ppb, which CASAC concluded could be supported by the scientific evidence, could reasonably be judged to be requisite to protect public health with an adequate margin of safety (Federal Register, 2014 – page 75309).

3. **In your testimony, you proposed that high levels of background in the mid-range concentrations would influence the margin of safety that the Administrator will use to establish the standard. Could you please expand on how background influences this margin of safety?**

The Administrator has proposed an 8-hour ozone human health standard somewhere in the range of 65-70 ppb and is taking comment on whether the standard should be set as low as 60 ppb. As I have noted in my response to Question 2, the Administrator (Federal Register, 2014 – page 75288) has clearly focused on the Schelegle et al. (2009) experiment that exhibited a combination of lung function decrements and respiratory symptoms at 72 ppb. If the Administrator believes that limitations associated with the Schelegle et al. (2009) experiment (e.g., see Lefohn, Hazucha, Shadwick, and Adams, 2010a) are not sufficient enough to prevent her from using the results from the experiment, I anticipate that she will combine the Schelegle et al. (2009) results with a margin of safety to set the ozone standard. The mortality/morbidity (i.e., epidemiological) and lung-function risk estimates, both of which are affected by background concentrations, are a part of the margin of safety determination in that the margin of safety the Administrator applies represents a cushion below the lowest observed adverse health effect that reflects uncertainties in the data. However, when the Administrator applies the margin of safety, she should be aware that background ozone contributes a significant amount to the observed total ozone concentrations for the levels of the standard she is considering. The consequences of this large contribution from background are that the margin of safety cushion the Administrator has to work with is small and that substantial emission reductions would have to be made to attain some of the standard levels she is considering as indicated by EPA (2014b).

Before detailing my comments on the relationship among background concentrations, health risks, and the margin of safety, I would like to mention two points. First, it is important to remember that anthropogenically derived ozone is not emitted as a pollutant. Rather, in most cases, it is formed from volatile organic hydrocarbon and nitrogen oxide pollutants in the presence of sunlight and warm temperatures (i.e., photochemical ozone production). Second, background ozone concentrations experienced at anthropogenically influenced sites (e.g., most population centers in the U.S.) will rise as emissions are reduced due to the chemistry among constituents of the atmosphere.

Although the Administrator did not rely on the epidemiology studies for proposing the levels of the standard (Federal Register, 2014 – page 75288), because EPA modeled health effects associated with epidemiological studies are predicted to occur at low ozone concentrations, I will first discuss how background ozone affected the estimated epidemiology-based risk assessment as ozone precursor emissions were reduced for 12 urban case study areas. I will preface these comments by noting it is important to understand what happens to ozone concentrations when emissions are reduced. Figure 4 (EPA, 2014b) depicts plots whose values are based on ambient measurements (base), and values obtained showing attainment of 75, 70, 65 and 60 ppb standards. In general, the range of the composite monitor concentration distributions compressed in all 12 urban study areas as the air quality data were adjusted to meet lower alternative standard levels. In other words, the lowest values shifted upward, while the maximum values shifted downward, as evidenced by the compressed boxes and their respective whiskers that occur for each city as we move away from the base or current condition situation. This predicted behavior of the patterns estimated using EPA's modeling is similar to the trending patterns observed using empirical data (Lefohn et al., 1998; Oltmans et al., 2006; Lefohn et al., 2008; Oltmans et al., 2008; Lefohn et al., 2010b; Cooper et al., 2012; Oltmans et al., 2013).

As indicated in Figure 4, as anthropogenic emissions are reduced to attain the 75, 70, 65, and 60 ppb levels, the high and low ends of the ozone concentration distribution shift toward the mid-level values (i.e., the box and the whiskers for each city compress towards the midrange ozone concentrations). As low ozone concentrations increase due to reduced ozone precursor emissions, which destroy ozone, background ozone concentrations ***increase*** (Lefohn et al., 2014; EPA, 2014a; Dolwick et al., 2015). In other words, background ozone is not a fixed range of concentrations, but rather background is a varying range of concentrations, whose values ***increase*** as anthropogenic emissions are reduced. Less anthropogenic titration of background results in increased background levels. Thus, the greater the reduction needed to meet a more stringent standard, the greater the increase in background. For high-elevation sites in the western U.S. that are not heavily influenced by local or regional anthropogenic emissions, it would not be anticipated that ozone concentrations would change much as emissions were reduced elsewhere (Lefohn et al., 2014). In reviewing Figure 4, we see that for the anthropogenically influenced sites (i.e., all except Denver), a large percentage of the 8-hour average daily maximum concentrations (i.e., the range from the ends of each city's whiskers) occur in the 25-55 ppb range when attainment is achieved at the 75, 70, 65 and 60 ppb levels. The range of concentrations for the high-elevation site at Denver is greater due to substantial contributions from background. Background ozone at most of the sites that are illustrated in Figure 4 is bounded within the 25-55 ppb observed ozone range and background makes up a large percentage of the hourly average concentrations in this range (Lefohn et al. 2014).

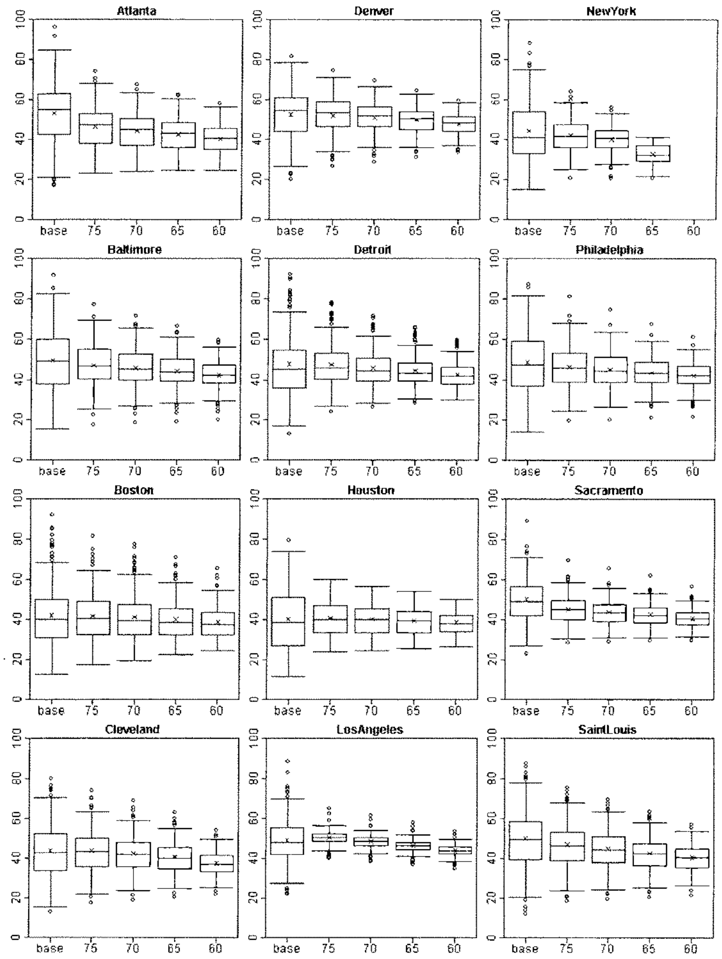


Figure 4. Distributions of composite monitor 8-hour daily maximum values for April-October 2007 for the 12 urban case study areas in the epidemiology-based risk assessment. Plots depict values based on "current" ambient measurements (base), and values obtained with the EPA adjustment methodology to attain standards of 75, 70, 65 and 60 ppb. Boxes represent the median and quartiles, X's represent mean values, whiskers extend up to 1.5x the inter-quartile range from the boxes, and circles represent outliers. (Source: Figure 4-9 from EPA (2014b) page 4-24).

For the mortality health risk estimates, the background-influenced concentrations in the mid-range (i.e., 25-55 ppb) dominate the risk after controlling precursor emissions to meet a proposed new standard (Lefohn and Oltmans, 2015). In some cases, 90% or more of the risk occurs in the mid-range for cities across the U.S. (Figure 5, the 12 cities included in EPA's epidemiological risk analysis). The height of the bars indicates that background ozone contributes a large percentage of the total ozone observed in the midrange (Lefohn, 2014) and the height increases as the possible new standard becomes more stringent.

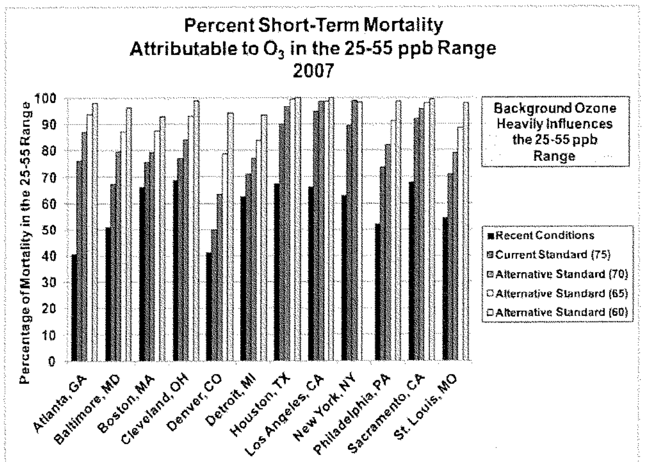


Figure. 5. Percent short-term ozone-attributable mortality in the 25-55 ppb range for various exposure conditions for 2007. (Source: Data from Fig. 7-B1 on page 7-B3 of EPA, 2014f).

Therefore, the mortality and morbidity risk estimates reported by EPA that are associated with attaining the current, as well as proposed lower standards, are heavily influenced by background ozone.

In my testimony, I stated that the Administrator has placed greater weight on controlled human exposure studies and the FEV_1 lung function decrement risk analyses rather than on the epidemiological results (Federal Register, 2014 – page 75288). In investigating the degree to which lung function risk estimates are affected by the background-influenced concentrations in the mid-range, we used the Air Pollutants Exposure (APEX) model to estimate children's lung function decrements under various air quality scenarios, relying on 2007 data for Los Angeles, Denver, Houston, Philadelphia, and Boston. For each of the 5 cities, five APEX scenarios (i.e., current conditions as of 2007, 75 ppb, 70 ppb, 65 ppb, and 60 ppb) were run. For 3 (i.e., Los Angeles, Denver, and Houston) of the 5 cities, we found that a large percentage of the frequency of responses was affected by background-influenced mid-range concentrations (Figure 6). While the concentrations in the 25-55 ppb range played less of a role in the lung function risk analysis for Philadelphia and Boston than for the other 3 cities, a great deal of the risk was associated with the 25-65 ppb range, especially for the 65 ppb and 60 ppb scenarios. Similar to the morbidity and mortality health risk estimates that are heavily influenced by background ozone in the 25-55 ppb range, the lung-function risk estimates for Los Angeles, Denver, and Houston also appear to be heavily influenced by background concentrations.

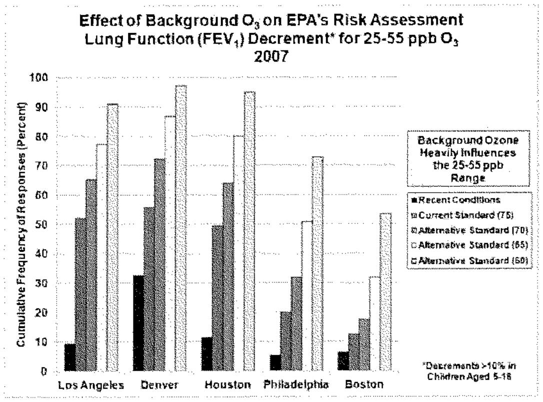


Figure 6. The percentage of the cumulative frequency of responses in children aged 5-18 associated with the 25-55 ppb range for the Los Angeles, Denver, Houston, Philadelphia, and Boston urban study areas using EPA's APEX model.

A point I would like to address is my certainty about the role of background ozone in (1) making important contributions to EPA's human health risk assessments; (2) greatly contributing at some sites to exceedances of the ozone standard; and (3) enhancing anthropogenic contributions at other sites which result in exceedances of the ozone standard.

As indicated in my testimony on March 17, 2015 and in my response to Question 3, I am confident that background ozone makes an important contribution to EPA's mortality and morbidity risk estimates. For lung function risk estimates, background ozone is an important contributor for some cities.

The evidence for the importance of background ozone in contributing to exceedances of lower ozone standards can be found in both empirical as well as modeling results. As indicated in my response to Question 1, modeling indicates that as emissions are reduced to attain the lower standard levels, many sites may experience violations during the spring. Spring is the time when background ozone across the U.S. is highest. Using empirical data, Lefohn et al. (2001) showed that at rural sites across southern Canada and the northern U.S., hourly average ozone concentrations ≥ 0.05 and ≥ 0.06 ppm occurred frequently during the winter and spring months. The analysis was concentrated on these higher latitudes during the late winter and spring because this is the period of low photochemical ozone production. In some cases, a plausible explanation for the higher ozone values was the presence of upper tropospheric and stratospheric air that was transported down to the surface. Lefohn et al. (2001) indicated that stratospheric processes (i.e., a naturally occurring process and therefore, a contributor to background) appeared to play an important role in influencing surface ozone concentrations during the winter and spring.

Yellowstone National Park, a site fairly isolated from anthropogenic sources of ozone, is an example of a location where background concentrations greatly contribute to exceedances of the proposed standard. The site at times violates a proposed 8-hour ozone standard of 65 ppb. Similarly, other sites in the Intermountain West and West would violate a standard in this range (see Lefohn and Oltmans, 2015 for list of peer-review publications). In many instances, background ozone greatly contributes to these exceedances. Our international research team (Lefohn et al., 2011, 2012, 2014), as well as other researchers, have estimated the relative importance of natural processes (e.g., stratospheric intrusions) that play an important role in influencing background ozone concentration levels on a daily basis over an entire year.

Lastly, as I showed in my response to Question 1, as emissions are reduced across the U.S. to meet alternative standards, simulated annual 4th highest (H4 MDA8) concentrations tend to shift from predominantly summer month occurrences (i.e., June, July, and August) over most of the U.S. to a wider range of months, particularly during the spring months. The appearance of violations during the spring months, which traditionally exhibit lower ozone concentrations compared to the summer months, is an indication that *background* ozone, which at most high- and low-elevation locations is highest during the spring, will be a major contributor to violations of the lowered proposed standard at sites across the entire U.S.

Based on our own modeling efforts, as well as others, combined with trending results using empirical data, I am confident of the following:

- As emissions are reduced, background will increase its contribution to observed exceedances of the standard across the entire U.S.;
- As emissions are reduced, exceedances of lower standards at low-elevation anthropogenically affected sites across the entire U.S. will occur during the spring, as well as the summer months;
- As emissions are reduced at low-elevation anthropogenically influenced sites, the range of concentrations between the highest and lowest will narrow and the number of mid-range concentrations (i.e., 25 – 55 ppb) will increase;
- As emissions are reduced, the large contribution of background in these mid-range concentrations will grow as standards become more stringent;
- As emissions are reduced, EPA's current estimates of mortality and morbidity health risk will be heavily influenced by background ozone; and
- As emissions are reduced, EPA's current lung function risk estimates appear to be heavily influenced by background ozone in some cities.

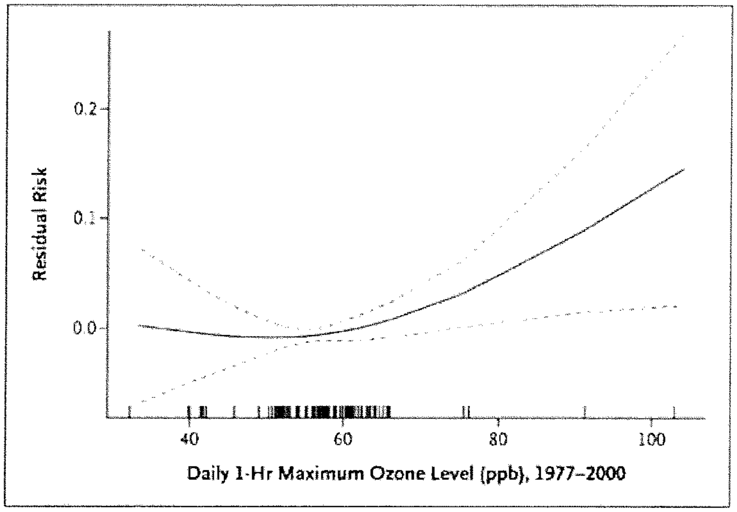
The margin of safety determination, which is influenced by the Agency's risk estimates, will assist the Administrator in establishing the level of the NAAQS ozone. Background ozone contributes to EPA's estimated health risks, as well as influencing the amount of emission reductions required to attain a specific standard level. The lower the standard, the greater influence background will have on the level of the standard. Sufficient advances have been made over the last few years to permit characterizing the range of background ozone concentrations. We now better understand quantitatively how background concentrations influence human health risk analyses and attainability. We know that background ozone will greatly influence attainability in the West and Intermountain West. However, besides concerns about attainability in the West, modeling is also showing that as emissions are reduced to attain lower standards, background ozone, which is highest in the spring at many locations across the U.S., will play an even more important role in contributing to exceedances of the standard across the entire U.S. during the spring months. Background is a part of the margin of safety consideration. As indicated in my response to a question during the March 17, 2015 Hearing, because background ozone contributes a significant amount to the observed concentrations, substantial emission reductions will have to be made to attain some of the standard levels that the Administrator is considering (EPA, 2014b).

For assisting in the further clarification of the importance of background ozone, I have included as an attachment to my responses the Lefohn and Oltmans (2015) comments that were submitted on March 16, 2015 to the Docket ID No. EPA–HQ–OAR–2008–0699.

4. **In the 2009 New England Journal of Medicine Paper by Jerrett et al ("Long-term ozone exposure and mortality"), there is a figure entitled "Exposure-Response Curve for the Relation between Exposure to Ozone and the Risk of Death from Respiratory Causes." The units of the x-axis are in terms of the "Daily 1-Hr Maximum Ozone Level (ppb)." What would happen if the x-axis was based on units of the "Daily 8-Hr Maximum Ozone Level (ppb)"? How would it change the conclusion of this figure? What is the significance of using the "Daily 8-Hr Maximum Ozone Level"?**

Dr. Rice testified that there is now stronger evidence of increased mortality in association with higher ozone levels, particularly among the elderly and those with chronic disease. Dr. Rice presented a figure published by Jerrett et al. (2009) in the *New England Journal of Medicine* that she believed demonstrated dose-response relationship between ozone levels and death from respiratory causes. She pointed out that there appeared to be a linear relationship between ozone concentration and risk of respiratory death above levels of 60 ppb. The figure on the next page is reproduced from her testimony.

Exposure–Response Curve for the Relation between Exposure to Ozone and the Risk of Death from Respiratory Causes



Dr. Rice reproduced the figure from Figure 2 from the Jerrett et al. (2009) paper on page 1094. The legend for Figure 2 in Jerrett et al. (2009) notes that the curve is based on a natural spline with 2 df estimated from the residual relative risk of death within a metropolitan statistical area (MSA), according to a random-effects survival model. The dashed lines indicate the 95% confidence interval of fit, and the hash marks indicate the ozone levels of each of the 96 MSAs.

On page 1086, Jerrett et al. (2009) note that ozone data at each monitoring site were collected on an hourly basis, and the daily maximum value for the site was determined. All available daily maximum values for the monitoring site were averaged over each quarter year. The averages of the second (April through June) and third (July through September) quarters were calculated for each monitor if both quarterly averages were available. The average of the second and third quarterly averages for each year was then computed for all the monitors within each metropolitan area to form a single annual time series of air-pollution measurements for each metropolitan area for the period from 1977 to 2000. The long-term average ozone concentration for each metropolitan area over the 1977 to 2000 time interval ranged from 33.3 ppb to 104.0 ppb.

Although it is not clearly indicated on the x-axis of Figure 2 in Jerrett et al. (2009), it appears that the evidence (i.e., Figure 2 from Jerrett et al., 2009) cited by Dr. Rice as indicating an effects threshold below 60 ppb is based on the long-term mortality risk relationship described by Jerrett et al. (2009). In the Supplement (page 8) to the Jerrett et al. (2009) paper, the authors state "Inclusion of 0 ppb in the confidence interval, a value less than the minimum ozone concentration of 33 ppb, indicates that the threshold model is not clearly a better fit to the data (p>0.05) than a linear representation of the overall ozone mortality association (see Table 3S below)." The reference to the 33 ppb in the Supplement in Jerrett et al. (2009) appears to indicate to me that the authors used the multi-year seasonal averages of the 1-h daily maximum concentrations over the period 1977 to 2000. The form of the NAAQS is associated with the 3-year average of the annual 4th highest daily maximum 8-hour average concentration. The 8-hour average metric is different from the multi-year long-term average ozone concentration used by Jerrett et al. (2009). The use of the multi-year long-term average has nothing to do with identifying a threshold below a NAAQS level of 60 ppb. The threshold estimate from the Jerrett et al. (2009) study cannot be used as evidence to support an 8-hour 60 ppb standard.

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Appendix A

Details of the ENVIRON Modeling for Assessing Seasonal Variability of Violations

For the Regulatory Impact Analysis (RIA), EPA (2014d) ran CAMx employing the CB6r2 photochemical mechanism. This is allowed because CB6r2 is backward-compatible with CB05 emissions. However, ENVIRON's modeling was conducted using CB05. Additionally, ENVIRON removed wildfire emissions from this analysis. Fire activity in 2011 was extensive and widespread throughout the western U.S. (especially Mexico, Arizona, New Mexico, Oklahoma and Kansas), and likely unrepresentative of a "normal" year. EPA extended 2011 fire emissions estimates to the 2018 and 2025 future year inventories without modification. ENVIRON's initial NOx reduction modeling exhibited little response in ozone Design Values (DV) in fire-affected areas, resulting in the need to remove nearly 100% of anthropogenic NOx in these states to reach the 60 ppb standard. ENVIRON's decision to remove this source reduced potential single-year biases in future year projections of ozone air quality.

Modeling for the year 2018 employed the Higher-order Decoupled Direct Method (HDDM) to estimate state-level NOx reductions necessary to meet 60 and 70 ppb ozone alternative standards throughout the U.S. The HDDM modeling followed the methodology developed by Yarwood et al. (2013). HDDM generated 2nd-order "sensitivities", i.e. the non-linear rate of ozone change per change in nationwide NOx emissions, at every model grid cell (12 km resolution) and for every hour of the annual simulation. ENVIRON held VOC emissions constant at projected 2018 estimates and only reduced NOx. Similarly to EPA's approach in the RIA, California and Texas were split to more appropriately account for sub-regional emission influences in these expansive states. Once a state-level NOx inventory was identified that was projected (via HDDM) to approach the target ozone standard at most monitoring sites across the U.S., CAMx was run in "brute force" mode with those NOx reductions to confirm compliance. Since HDDM is not exactly equivalent to "brute force" simulations, two iterations of CAMx simulations were necessary to refine the NOx estimates.

Simulated daily baseline (2011) MDA8 ozone and 2018 ozone projections from State-level NOx reductions were supplied to EPA's Modeled Attainment Test Software (MATS). MATS calculated "relative response factors" (RRF) from the baseline and projected MDA8 at each active AQS and CASTNET monitoring site (as of 2013) throughout the conterminous U.S., and applied the RRF to each site's 3-year average design value (DV) centered on 2011 (i.e., the average DV from 2009-2011, 2010-2012, and 2011-2013 DV). MATS reported projected DV at each active site, along with interpolated DV across the modeling grid. This approach is equivalent to the methodology followed by EPA in the RIA. However, EPA used the latest version of MATS that conforms to recently issued modeling guidance (EPA, 2014e), whereas ENVIRON's analyses continued with the previous version of MATS that conforms to the original 2007 modeling guidance (EPA, 2007). Final CAMx runs were conducted to iterate on achieving a 3-year average DV of 60 and 70 ppb (±2 ppb) at the peak site in each state. While 60 ppb was achieved at all but a handful of monitoring sites, the spatially interpolated DV continued to exceed the 60 ppb standard in wide areas of the west. Final DVs above 60 ppb are attributed to background ozone sources, including inter-continental transport (via model boundary conditions), stratospheric intrusions, fires in Mexico, and off-shore sources that were not reduced (e.g., shipping, off-shore O&G production, etc.).

The largest remaining exceedances in the western U.S. are attributed to background sources. In the final iteration of the NOx inventory, additional NOx reductions were estimated for several western States via extrapolation between multiple brute force NOx iterations. Additional NOx reductions were applied in West Texas and New Mexico; however, the statewide peak DV did not change from 66 ppb in West Texas, and marginally changed by 2 ppb in New Mexico. Extrapolation for other western States indicated that more than 100% NOx reductions would have been necessary to achieve DVs of 60 ppb in California, Colorado, and Wyoming. Given the stiffness in DV ozone response from these results, no additional NOx reductions were considered.

Background Ozone and Its Importance to the Proposed National Ambient Air Quality Standards for Ozone

Allen S. Lefohn*
A.S.L. & Associates
302 North Last Chance Gulch, Suite 410, Helena, Montana 59601
asl-associates.com

Samuel J. Oltmans†
1619 Pine Street, Boulder, Colorado 80302

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Executive Summary

ES-1. Our Conclusions

Based on information published in the literature and by EPA (2014a,b,c,d,e,f), we conclude the following:

- As emissions are reduced, background will contribute more to observed exceedances of the standard;
- As emissions are reduced, the range of concentrations between the highest and lowest will narrow and the number of mid-range concentrations (i.e., 25 – 55 ppb) will increase;
- The large contribution of background in the mid-range will grow as proposed standards become more stringent;
- As emissions are reduced, EPA's cumulative mortality and morbidity health risk will be heavily influenced by background O_3;
- As emissions are reduced, EPA's cumulative lung function risk estimates appear to be heavily influenced by background O_3 in some cities; and
- The margin of safety determination, which is tightly linked with risk estimates, will guide the Administrator in establishing the level of the NAAQS O_3. The margin of safety is influenced by background O_3.

ES-2. Why is Background Ozone Important in the Standard-Setting Process?

The U.S. EPA is proposing standards (Federal Register, 2014) at levels where resulting concentrations will be heavily influenced by background ozone (O_3). EPA notes in its Policy Assessment document (EPA, 2014a; page 1-27) that EPA staff did not consider proximity to background O_3 concentrations. However, EPA staff acknowledged that the Administrator, when evaluating the range of possible standards that are supported by the scientific evidence, could consider proximity to background O_3 concentrations as one factor in selecting the appropriate standard level (EPA, 2014a, page 1-27; Federal Register, 2014, page 75242). In its 1997 decision, EPA (Federal Register, 1997 page 38868) noted that a standard set at a level of 0.07 ppm would be closer to peak background concentrations that infrequently occur in some areas due to non-anthropogenic sources of O_3 precursors and the Agency set the O_3 NAAQS at 0.08 ppm.

EPA (Federal Register, 2014 page 75383) agrees that there is no question that as the levels of alternative prospective standards are lowered, background will represent increasingly larger percentages of total O_3 levels and may subsequently complicate efforts to attain these standards. If lower standard levels were promulgated, background will increase and exceedances will become more common. Exceedances of lower proposed standards at times may be associated with natural stratospheric-dominated enhancements to observed surface O_3 concentration (i.e., episodes), while at other times exceedances may be associated with natural stratospheric-contributed enhancements combining with other sources, such as anthropogenic emissions.

Background O_3 is continually contributing to observed concentrations that influence human health and vegetation risk estimates across the entire U.S. The EPA Administrator utilizes controlled human exposure studies and mortality/morbidity and lung-function risk estimates for assessing the health impact of O_3. This information is used to establish the level of the primary standard. The controlled human exposure studies provide the Administrator with an initial consideration for the level at which the health standard could be set. The risk estimates provide further clarification to the Administrator for refining her initial consideration and provides a margin of safety associated with her final decision on the O_3 NAAQS. In order to make an informed decision on the level of the O_3 health standard, it is important that the EPA Administrator recognize the relative importance of background O_3 and how it relates to observed O_3 levels.

ES-3. What Happens to Ozone Concentrations When Emissions are Reduced to Attain the Proposed Ozone Standards?

Simulation of just meeting the existing and proposed O_3 standards has been estimated by the EPA by adjusting hourly O_3 concentrations measured over the O_3 season using a model-based adjustment methodology that estimates O_3 sensitivities to precursor emissions changes (EPA, 2014a). Efforts to control O_3 by reducing its precursor emissions will not only have the desirable effect of reducing peak O_3 concentrations, but will cause the low level concentrations to shift upward. This is to be expected and was discussed in Lefohn et al. (1998) and reported by several investigators using empirical data (Oltmans et al., 2006; Lefohn et al., 2008; Oltmans et al., 2008; Lefohn et al., 2010; Oltmans et al., 2013). The result is that O_3 concentrations in the mid range (i.e., 25-55 ppb) will become more frequent. Background O_3 makes up a large percentage of the observed O_3 in this range (Lefohn et al., 2014). EPA (2014b,c) reports that the mid-range concentrations (25-55 ppb) dominate the Agency's mortality risk estimates.

ES-4. What is EPA's Conclusion about the Relative Importance of Background Ozone?

The EPA (2014a) reports that background O_3 makes up a relatively large percentage (e.g., 70 to greater than 80%) of the total seasonal mean O_3 in locations within the intermountain western U.S. and along the northern and southern U.S. border over the April-October period (orange and red circles) (Fig. ES-1). For many low-elevation sites in the West, the contribution of background ranges from 50% to greater than 80% (EPA, 2014a; Dolwick et al., 2015). For the remainder of the U.S., from 50% to greater than 80% consists of background (Green-, yellow-, orange- and red-colored circles). Our own published findings (Lefohn et al., 2014) agree with EPA's conclusions.

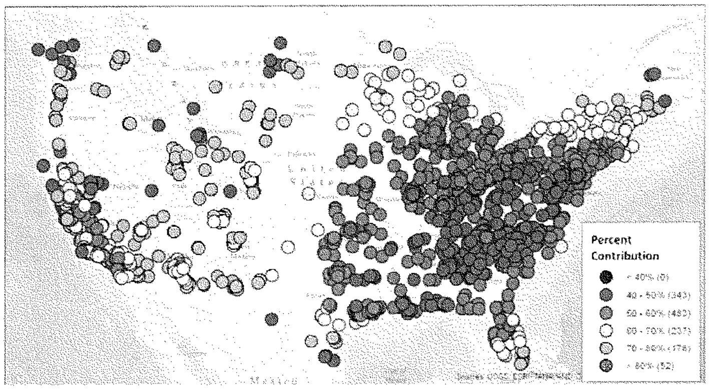

Fig. ES-1. Map of site-specific ratios of apportionment-based U.S. background to seasonal mean O_3 (April-October) based on 2007 CAMx source apportionment modeling. (Source: page 2-22 of EPA's Policy Assessment Document (EPA, 2014a)).

ES-5. How Much Does Background Ozone Contribute Within Specific Concentration Ranges?

Yellowstone National Park, located in Wyoming, is an excellent reference site to identify the characteristics of background. Yellowstone is dominated by background O_3 throughout the year with minor anthropogenic contributions (Lefohn et al., 2014). At this site, background contributes greater than 80% to the current observed O_3 concentrations (Fig. ES-2), including the mid-range (25-55 ppb), which is an important range of concentrations that affect human health risk estimates.

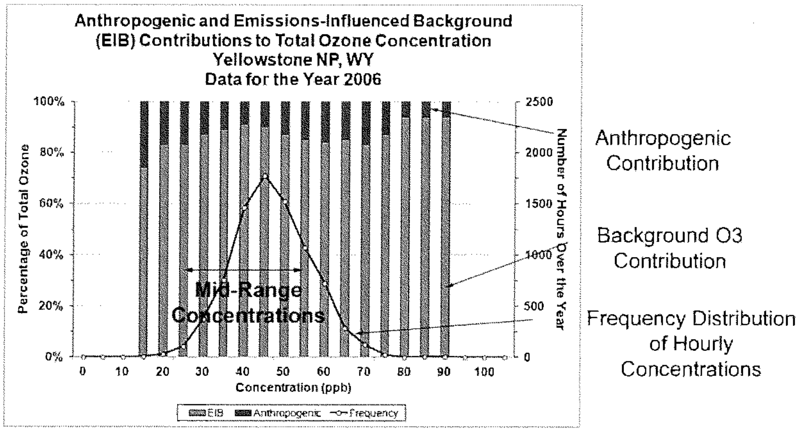

Fig. ES-2. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB and anthropogenic O_3 (bars; left axis) for Yellowstone NP. (Source: Lefohn et al., 2014).

For Denver, Colorado, the contribution of background is more than 50% across all concentrations and within the mid-range concentrations, background contributes approximately 75 to 80% (Fig. ES-3). For many of the low-elevation sites across the U.S., the contribution of background is 50% and higher for the mid-range (Lefohn et al., 2014). For Los Angeles, a site heavily influenced by anthropogenic emissions, background contributes 60-80% in the mid-range (Fig. ES-4).

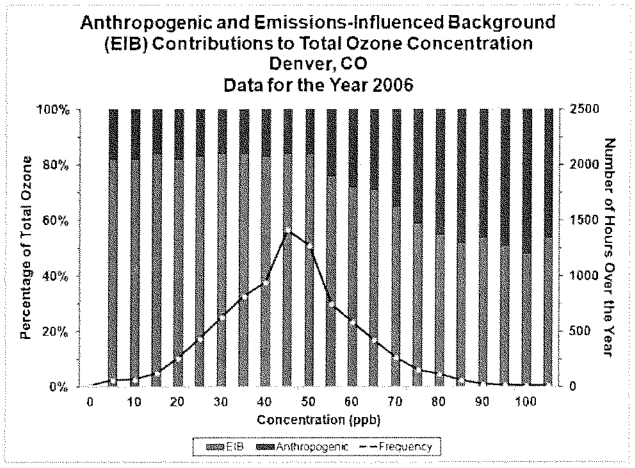

Fig. ES-3. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB (blue) and anthropogenic (red) O_3 (bars; left axis) for ambient conditions in 2006 at Denver, Colorado. (Source: Lefohn et al., 2014).

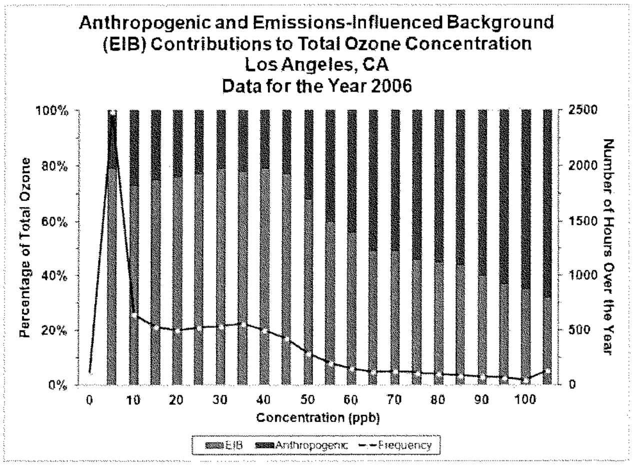

Fig. ES-4. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB (blue) and anthropogenic (red) O_3 (bars; left axis) for ambient conditions in 2006 at Los Angeles, California. (Source: Lefohn et al., 2014).

ES-6. What is EPA's Position about Exceedances of More Stringent Standards?

EPA's position is that exceedances of more stringent standards caused by background will be relatively infrequent and thus, the Agency will be able to exclude air quality monitoring data from design value calculation (Federal Register, 2014 page 75242). The EPA cites its work to reduce international transport of O_3 and other pollutants that contribute to background O_3 levels under the Convention on Long-Range Transboundary Air Pollution (LRTAP) of the UN Economic Commission for Europe, as well as other international efforts, will lead to reductions of background O_3 (Federal Register, 2014 page 75372).

However, EPA's position on controlling background is not necessarily well established and overlooks the relative importance of the contribution to background O_3 from long-range transport of anthropogenic emissions versus natural stratospheric intrusions. The dominant contribution from the stratosphere in comparison to other sources of background suggests that international emission reductions may not be an effective tool for reducing background O_3 (Lin et al., 2012a, 2012b; Langford et al., 2014) and raises questions as to how effective exceptional event categorization and procedures for establishing such an event will be in excluding air quality monitoring data that fall in the 65-70 ppb MDA8 range, especially at sites in the western U.S. Most of the events that might currently be classified as exceptional events under the current MDA8 standard of 75 ppb or under the proposed stricter standard appear to have a substantial contribution from O_3 with an initial source in the stratosphere (Lefohn et al., 2014; 2015). As noted in Langford et al. (2014) from a recent research field investigation in Clark County, Nevada "exceedances of the NAAQS (for a 65 ppb standard) generated by high background concentrations and stratospheric intrusions would have occurred on 60% of the days during LVOS (Las Vegas Ozone Study), making these events the rule rather than the exception." In the only documented case accepted by the EPA of an exceptional event attributed to substantial stratospheric influence, a document exceeding 100 pages was filed The practicality of submitting 100 page documents each time an exceedance of the standard occurs that is associated with natural stratospheric intrusions is questionable.

Potential strategies, such as international agreements to control emissions contributing to long-range transport of O_3 that produce high background O_3, do not hold up to careful scrutiny. Results published in the literature indicate large discrepancies in the attribution of the levels of Asian pollution O_3 to background O_3. These discrepancies are a topic that requires further research. It is unclear what effect international emission reductions would have on surface O_3 concentrations in the U.S. Results published in the peer-reviewed literature indicate that natural stratospheric intrusion enhances surface O_3 4-5 times greater than O_3 associated with the long-range transport from Asia. Therefore, it is unclear if background O_3 could be substantially reduced because of the contribution from uncontrollable, natural sources of O_3.

ES-7. How does background influence the EPA's human health risk estimates?

The EPA Administrator utilizes controlled human exposure studies and mortality/morbidity and lung-function risk estimates for assessing the health impact of O_3. This information is used to establish the level of the primary standard. The mid-range concentrations currently measured, which are heavily influenced by background, play an important role in human health risk estimates. As O_3 precursor emissions are reduced to meet more stringent standards, EPA (2014b) notes that O_3 concentrations in the mid-range will occur more frequently and therefore, play even a more important role in the risk estimates.

For the mortality health risk estimates, the background-influenced concentrations in the mid-range dominate the cumulative risk (Fig. ES-5). In some cases, 90% or more of the accumulated risk occurs in the mid-range for cities across the U.S. The figure illustrates this for seven cities. Similar results occur for the remaining 5 cities used in the epidemiological risk analyses.

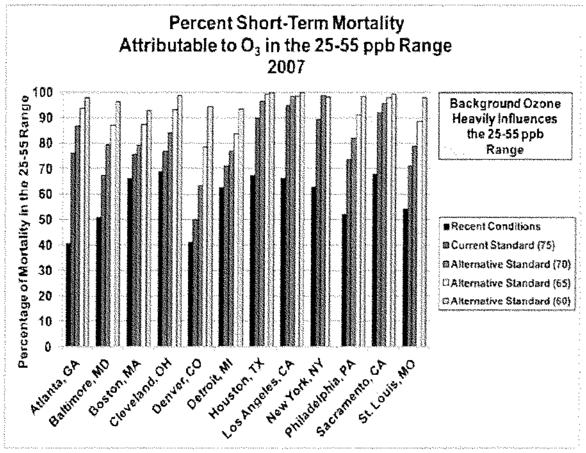

Fig. ES-5. Percent short-term O_3-attributable mortality in the 25-55 ppb range for various exposure conditions for 2007. (Source: Data from Fig. 7-B1 on page 7-B3 of EPA, 2014e).

The Administrator has placed greater weight on controlled human exposure studies and the FEV1 lung function decrement risk analyses rather than on the epidemiological results (Federal Register, 2014 page 75288). We investigated the degree to which lung function risk estimates are affected by the background-influenced concentrations in the mid-range. The Air Pollutants Exposure (APEX) model was used to estimate children's lung function decrements under various air quality scenarios using 2007 data for Los Angeles, Denver, Houston, Philadelphia, and Boston. For each of the 5 cities, five APEX scenarios (i.e., current conditions as of 2007, 75 ppb, 70 ppb, 65 ppb, and 60 ppb) were run. For 3 (i.e., Los Angeles, Denver, and Houston) of the 5 cities, we found a large percentage of the cumulative frequency of responses was affected by background-influenced mid-range concentrations (Fig. ES-6). While the concentrations in the 25-55 ppb range played less of a role in the cumulative lung function risk analysis for Philadelphia and Boston than for the other 3 cities, a great deal of the accumulated risk was associated with the 25-65 ppb range, especially for the 65 ppb and 60 ppb scenarios.

Similar to the morbidity and mortality health risk estimates that are heavily influenced by background O_3 in the 25-55 ppb range, the cumulative lung-function risk estimates for Los Angeles, Denver, and Houston also appear to be heavily influenced by background concentrations.

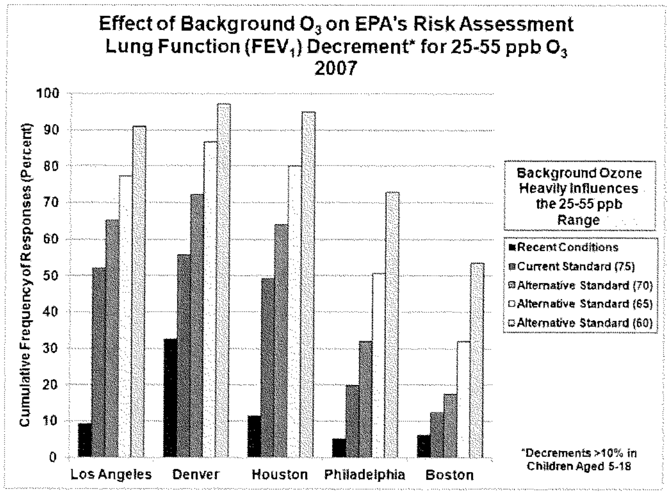

Fig. ES-6. The percentage of the cumulative frequency of responses in children aged 5-18 associated with the 25-55 ppb range for the Los Angeles, Denver, Houston, Philadelphia, and Boston urban study areas using EPA's APEX model.

ES-8. Final Comment

As we have discussed above, we believe that background O_3 should be a serious consideration when evaluating the evidence for setting the O_3 NAAQS for the protection of human health across the entire U.S. Background O_3 is much more than a regional attainment problem in the West and Intermountain West. The EPA Administrator utilizes mortality/morbidity and lung-function risk estimates to provide her with a refinement of her initial consideration of the O_3 NAAQS based on controlled human exposure studies. These risk estimates provide key information for assessing the margin of safety that is overlaid with results from the human exposure studies. In order to make an informed decision on the level of the O_3 health standard, it is important that the EPA Administrator recognize the importance of background O_3 and how it influences the margin of safety.

1. Background and Why It Is Important for the Ozone Standard-Setting Process

The U.S. EPA is proposing standards (Federal Register, 2014) at levels where resulting concentrations will be heavily influenced by background ozone (O_3). EPA notes in its Policy Assessment document (EPA, 2014a; page 1-27) that EPA staff did not consider proximity to background O_3 concentrations. However, EPA staff acknowledged that the Administrator, when evaluating the range of possible standards that are supported by the scientific evidence, could consider proximity to background O_3 concentrations as one factor in selecting the appropriate standard level (EPA, 2014a, page 1-27; Federal Register, 2014, page 75242). In its 1997 decision, EPA (Federal Register, 1997 page 38868) noted that a standard set at a level of 0.07 ppm would be closer to peak background concentrations that infrequently occur in some areas due to non-anthropogenic sources of O_3 precursors. EPA (Federal Register, 2014 page 75383) agrees that there is no question that as the levels of alternative prospective standards are lowered, background will represent increasingly larger percentages of total O_3 levels and may subsequently complicate efforts to attain these standards.

At times, background is responsible for the high concentrations observed in the U.S. Intermountain West that affects attainability of O_3 air quality standards (Lefohn et al., 2001; Langford et al., 2009; McDonald-Buller et al., 2011; Lin et al., 2012a; Langford et al., 2014). In addition, background O_3 is a contributor on a continuous basis to observed concentrations that influence human health and vegetation risk estimates across the U.S. These risk estimates influence the EPA Administrator's recommendation for federal O_3 standard levels (McDonald-Buller et al., 2011; EPA, 2014a, 2014b; Federal Register, 2014). Exceedances of the O_3 standard at times may be associated with natural *stratospheric-dominated* enhancements to observed surface O_3 concentration (i.e., episodes), while at other times exceedances can be associated with natural *stratospheric-contributed* enhancements that combine with other sources, such as anthropogenic emissions. In order to make an informed decision on the level of the O_3 health standard, it is important that the EPA Administrator recognize the relative importance of background O_3 and how it relates to observed O_3 levels. Background O_3 affects the (1) human health risk estimates, (2) attainability of Federal O_3 standards, and (3) benefits accrued from possible emission reductions.

As indicated in our written communications to the EPA and CASAC (Lefohn and Oltmans 2012; 2014a,b,c,d,e), background provides a significant contribution to observed O_3 and plays a major role in influencing health risk estimates, as well as attainment of O_3 National Ambient Air Quality Standards (NAAQS). The EPA Administrator utilizes controlled human exposure studies and mortality/morbidity and lung function risk estimates for assessing the health impact of O_3. The controlled human exposure studies provide the Administrator with an initial indication of the level at which the health standard could be set. The risk estimates provide further clarification to the Administrator for refining her initial consideration and provide a margin of safety associated with her final decision on the O_3 NAAQS. It is imperative that the Administrator be aware and take into consideration to what degree background O_3 affects risk estimates used in her margin of safety considerations.

2. The Definitions of Background Ozone

In 2006, the EPA used models to define background O_3. EPA (2006) defined North American background (NAB) O_3 (previously referred to as Policy-Relevant Background by the EPA) to include contributions from global anthropogenic and natural sources in the absence of North American (i.e., U.S., Canada, and Mexico) anthropogenic emissions. The level of NAB O_3 defined the concentration or range of concentrations that EPA believed would be experienced if the United States and other countries in North America were to initiate a zero emissions strategy. In 2013, EPA (2013) introduced the terminology U.S. background (USB) O_3 concentrations by including anthropogenic contributions from Canada and Mexico. The difference associated with the hypothetical estimates of NAB O_3 and USB O_3 is small (EPA, 2013).

Recognizing that NAB O_3 and USB O_3 are estimated background concentrations that reflect hypothetical zero anthropogenic emissions, in late 2013, Lefohn et al. (2014) estimated background O_3 levels under current anthropogenic emission conditions. Lefohn et al. (2014), using source-apportionment based modeling, referred to these background estimates as Emissions-Influenced-Background (EIB) O_3. In August 2014, EPA (2014a) described estimates of source-apportionment U.S. Background (USB_{ab}), which is similar to the EIB O_3 concept introduced in late 2013 by Lefohn et al. (2014). Both the estimates by Lefohn et al. (2014) and EPA (2014a) reflect background concentrations under current emissions-influenced conditions. EPA (2014a) notes that the strength of the source-apportionment approach is that it provides a direct estimate of the amount of O_3 contributed by each source category, while avoiding artifacts caused by non-linearity in the chemistry, which is a potential with the zero emissions (i.e., zero-out) modeling used to estimate NAB O_3 and USB O_3 concentrations (EPA, 2014a). Estimates of both background EIB O_3 and USB_{ab} concentrations are equal to or less than estimated theoretical values using zero regional emissions (i.e., NAB O_3 and USB O_3). One important advantage of using both EIB O_3 and USB_{ab} background estimates is that the estimates provide the EPA Administrator and other policy makers with an indication of (1) the relationship between current daily background levels and daily observed O_3 concentrations and (2) whether emission reductions strategies might result in lowering observed O_3 levels at specific locations. For example, if EIB O_3 or USB_{ab} O_3 concentrations make up a large percentage of the observed O_3

concentrations at a specific site, one would anticipate that emission reductions on a regional scale would not have much impact on exposures at this site.

3. Estimated Ranges of Background Ozone Concentrations and the Percentage of Background Ozone in Observed Concentrations across the U.S.

Prior to 2006, O_3 measurements from remote monitoring sites were used to estimate background. EPA (1996) estimated that hourly average summer background concentrations were in the range of 30-50 ppb and used an average background of 40 ppb in its risk analyses. In 2006, EPA (2006) cited the work of Fiore et al. (2002, 2003), who applied the GEOS-Chem global model to estimate a much lower mean background concentration in the 15-35 ppb range. Lefohn et al. (2014) note that high-elevation sites in the Intermountain West, as well as some sites in the West, experience background levels as high as 8-hour maximum concentrations of 85 ppb. Lefohn and Oltmans (2012; 2014a,b,c,d,e) noted that background O_3 at low-elevation sites across the U.S. makes up a large percentage of observed O_3 over the range of 25-55 ppb, which is an important range of concentrations that influence the human health risk estimates. A detailed discussion of background is provided in Appendix A.

Background O_3 is a persistent feature in the spring and early summer across the U.S. and is likely not easily identifiable as exceptional events but rather as continuous contributions to surface O_3 concentrations that affect both attainment of the standard, as well as human health risk estimates. Published work (Zhang et al., 2011; Emery et al., 2012; Lin et al., 2012a, 2012b; Lefohn et al. 2014; Fiore et al., 2014; Langford et al., 2014; Dolwick et al., 2015) and ongoing research (Lefohn et al., 2015) quantify the important contribution that background O_3 makes to O_3 concentrations. Lefohn et al. (2014) note that background O_3 contributes a major portion to total O_3 for most sites across the U.S., especially during the spring. At western high-elevation sites, the contributions of daily background to total O_3 are usually greater than 70% over the entire year (Lefohn et al., 2014). Recent estimates by Dolwick et al. (2015) quantifying the importance of background at high-elevation sites in the western U.S. for the April-October 2007 period agree with conclusions reached by Lefohn et al. (2014). For many of the low-elevation sites across the U.S., the contributions of background are 50% and higher during non-summer months. Dolwick et al. (2015) report that for low-elevation sites in the western U.S., background O_3 contributes 40-60% to the highest 8-hour concentrations (i.e., top 10% values) (see light blue and green circles in Fig. 1). In some cases, the contribution is greater than this range for low-elevation sites (see yellow, orange, and red circles in Fig. 1).

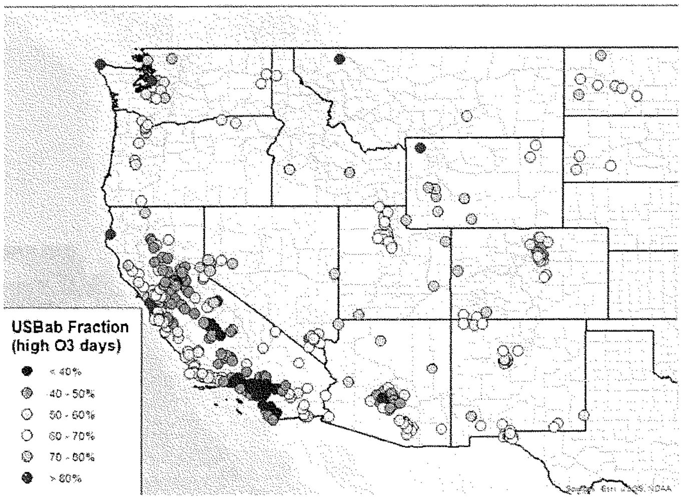

Fig. 1. CAMx-estimated USB_{AB} ozone fractions at monitoring locations across the western U.S. for the period April – October 2007, on base model days with MDA8 ozone > 90th percentile levels. (Sonrce: Dolwick et al., 2015).

Under current conditions, EPA (2014a) recently concluded in its Policy Assessment document (PA) that a large percentage (i.e., >50%) of 8-hour average concentrations measured across the U.S. consists of background O_3 based on the seasonal mean over the April-October period (see green, yellow, orange, and red colored circles in Fig. 2). At sites in the West, Intermountain West, and the Northeast, background contributes ≥ 70% to observed concentrations (see orange and red colored circles in Fig. 2). These EPA observations (EPA, 2014a) agree with the conclusions published by Lefohn et al. (2014). Dolwick et al. (2015), recently summarized the EPA (2014a) findings, confirms the importance of background O_3 at both high- and low-elevation sites in the western U.S.

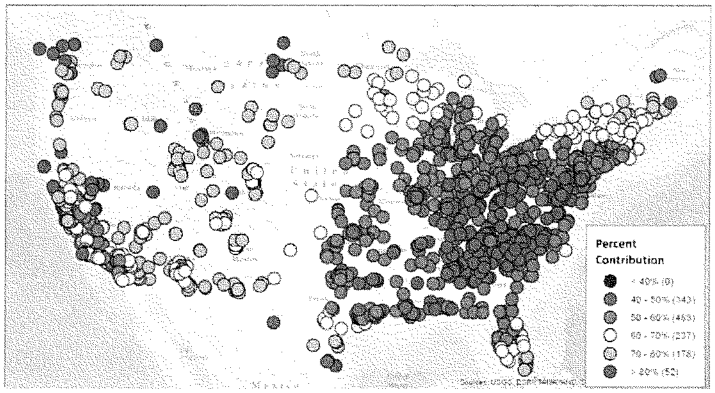

Fig. 2. Map of site-specific ratios of apportionment-based U.S. background to seasonal mean O_3 (April-October) based on 2007 CAMx source apportionment modeling. (Source: page 2-22 of EPA's Policy Assessment Document (EPA, 2014a)).

One of the important aspects of background O_3 is the contribution it makes to different ranges of the observed O_3 concentration distribution (i.e., at low concentrations, at mid concentrations, and at high concentrations). For the consideration of the attainment of the O_3 standard, as well as estimated human health risk assessments, the percent contribution of background O_3 to observed O_3 levels across the entire distribution of observed concentrations is important. Lefohn et al. (2014) investigated the percentage that background O_3 contributes to all observed concentrations. At high-elevation sites in the Intermountain West, the authors reported that the highest observed O_3 concentrations were influenced by over 90% background O_3. EPA (2014a) and Dolwick et al. (2015) noted similar percentage patterns (please see orange and red circled sites in Fig. 1 for the Intermountain West region).

For Yellowstone National Park (NP), Fig. 3 illustrates the contribution of background O_3 to total observed concentrations by concentration range. Lefohn et al. (2014) reported that Yellowstone NP in Wyoming was dominated by background O_3 throughout the year with minor anthropogenic contributions. The figure illustrates that background O_3 estimates for Yellowstone NP contribute in general greater than 80% to the observed O_3 concentrations measured across the entire distribution of hourly average O_3 concentrations. The figure illustrates the modeled contributions of hourly background to the total O_3. The frequency distribution (black curve) of the hourly average concentrations is represented by the black curve. The relative contribution of background (blue bar) to anthropogenic (red bar) is shown in the figure. At the highest concentrations, the contribution of background O_3 is greater than 95% of the total O_3 observed. Lefohn et al. (2014) note that the highest O_3 concentrations at this site appear to be associated with natural stratospheric intrusions. For the mid-range concentrations (25-55 ppb), the contribution of hourly background O_3 to total observed O_3 is greater than 80%. At the lower concentrations (i.e, below 25 ppb), the contribution of background O_3 is greater than 75%.

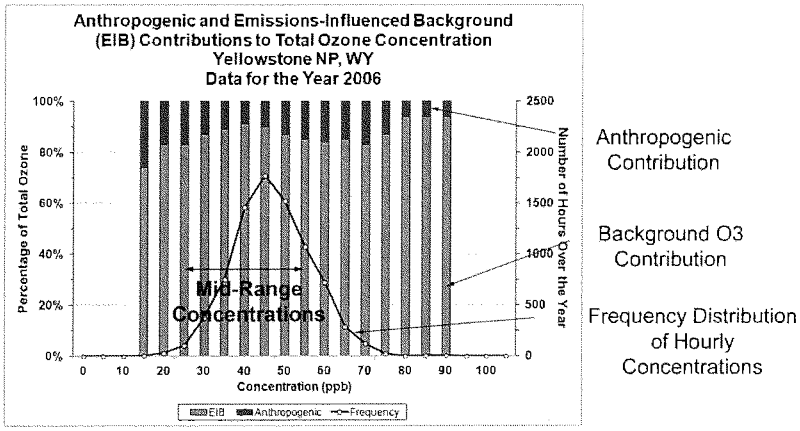

Fig. 3. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB and anthropogenic O_3 (bars; left axis) for Yellowstone NP. (Source: Lefohn et al., 2014).

Figure 4 illustrates the results from Lefohn et al. (2014) for the urban influenced high-elevation site at Denver, Colorado. Lefohn et al. (2014) note that background O_3 remained elevated, but that anthropogenic effects were evident, including the NO_X titration of O_3 at the lowest concentrations throughout the year and heightened O_3 production from local anthropogenic sources during the warm season. Background O_3 generally contributes greater than 50% at the highest concentrations at the Denver site and between 70-80% to total O_3 in the 25-55 ppb range, and greater than 80% between 15 and 25 ppb. For many of the low-elevation sites, the contributions of background O_3 were 50% and higher (see figures at end of Appendix A). Figure 5 illustrates the percent contribution of background O_3 to observed O_3 for the anthropogenically influenced site at Los Angeles. The site shows 60-80% contribution of background O_3 in the 25-55 ppb range. The site shows the heavy influence of anthropogenic emissions at the highest concentrations (i.e., red bars).

Lefohn et al. (2014) noted that at sites influenced by anthropogenic emissions under current emission conditions across the U.S., background O_3 contributed larger proportions to total O_3 during the spring, winter, and fall and that the contribution of background O_3 was lowest during the summer when the maximum concentrations occurred. The importance of background O_3 to observed O_3 values noted by Lefohn et al. (2014) is similar to the seasonally averaged (April-October) background O_3 percentages illustrated in Fig. 2 above that is reproduced from EPA's Policy Assessment Document (2014a).

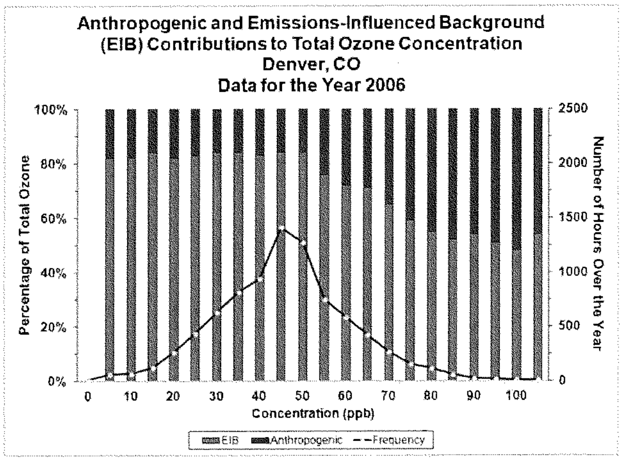

Fig. 4. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB (blue) and anthropogenic (red) O_3 (bars; left axis) for ambient conditions in 2006 at Denver, Colorado. (Source: Lefohn et al., 2014).

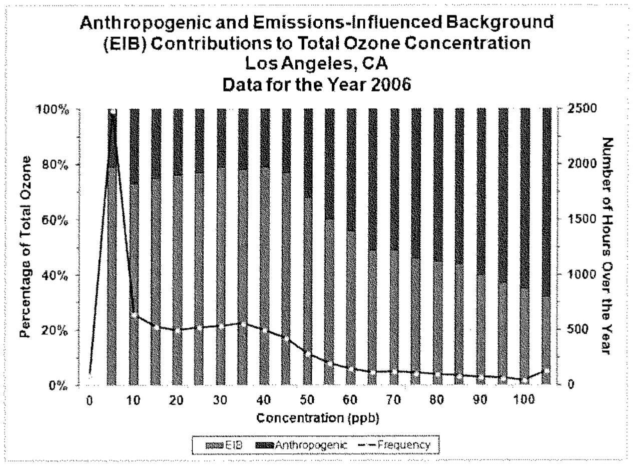

Fig. 5. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB (blue) and anthropogenic (red) O_3 (bars; left axis) for ambient conditions in 2006 at Los Angeles, California. (Source: Lefohn et al., 2014).

4. How Background Ozone and Observed Concentrations across the U.S. are Affected by Emission Reductions

Simulation of just meeting the existing and proposed O_3 standards has been estimated by the EPA by adjusting hourly O_3 concentrations measured over the O_3 season using a model-based adjustment methodology that estimates O_3 sensitivities to precursor emissions changes (EPA, 2014a). These sensitivities, which estimate the response of O_3 concentrations to reductions in anthropogenic NOx and VOC emissions, are developed using the Higher-order Decoupled Direct Method (HDDM) capabilities in the Community Multi-scale Air Quality (CMAQ) model (see EPA, 2014b for further details on the model).

Based on empirical data, we have a good understanding how observed O_3 concentrations change as anthropogenic emissions are reduced. As O_3 levels improve (i.e., the environment experiences reduced peak O_3 exposures) due to reduced emissions, reductions in the number of high hourly average concentrations, as well in the disappearance of low hourly average concentrations, occur (Lefohn et al., 1998). The disappearance in the number of low hourly average O_3 concentrations is associated with lack of NO_x scavenging (EPA, 1996). Lefohn et al. (1998) noted that as a site's air quality improves, the distribution of the hourly average concentrations shifts from both the high end, as well as the low end of the distribution, toward the middle concentrations (i.e., 30-60 ppb). Several investigators (Oltmans et al., 2006; Lefohn et al., 2008; Oltmans et al., 2008; Lefohn et al., 2010; Oltmans et al., 2013) reporting observed O_3 trends using empirical data , note shifts in the concentration distribution over time, where both the high and the low ends of O_3 concentrations shift toward the mid-level values. Figure 6 from Lefohn et al. (2010) illustrates for the period 1994-2008 how the concentrations shift by month for a site in San Bernardino (CA). The highest concentrations are reduced over time, while the middle concentrations increase, and the lower concentrations shift upward into the middle region.

Using the HDDM model, the EPA estimated the changes in 8-hour daily maximum concentrations that would occur as emissions were reduced for 12 urban case study areas evaluated in the epidemiology-based risk assessment. Figure 7 depicts plots whose values are based on ambient measurements (base), and values obtained with the HDDM adjustment methodology showing attainment of 75, 70, 65 and 60 ppb standards. Boxes represent the median and quartiles, X's represent mean values, whiskers extend up to 1.5x the inter-quartile range from the boxes, and circles represent the outliers. In general, the range of the composite monitor distributions decreased (i.e., the lowest values shifted upward, while the maximum values shifted downward) in all 12 urban study areas as the air quality data were adjusted to meet lower alternative standard levels. The predicted behavior estimated using the HDDM modeling is similar to the observed trending patterns observed using empirical data (Lefohn et al., 1998; Oltmans et al., 2006; Lefohn et al., 2008; Oltmans et al., 2008; Lefohn et al., 2010; Oltmans et al., 2013).

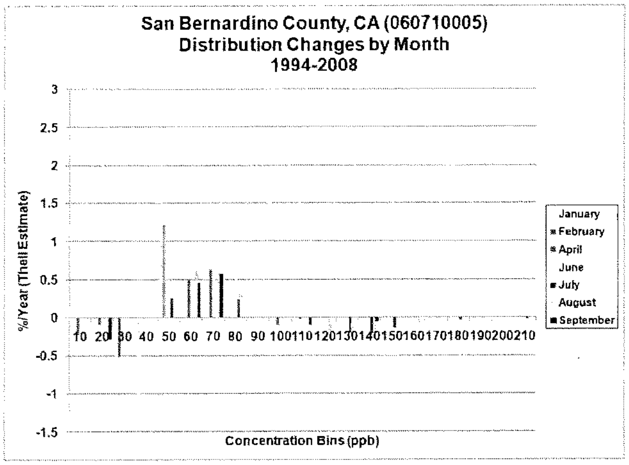

Fig. 6. Distribution changes by month for a monitoring site located in San Bernardino County, California (AQS 060710005) for 1994-2008 for the months with statistically significant changes. (Source: Lefohn et al., 2010).

As indicated in Fig. 7, as anthropogenic emissions are reduced to attain the 75, 70, 65, and 60 ppb levels, the high and low ends of the O_3 concentration distribution shift toward the mid-level values. There is a compression of the high and low ends of the distributions. For areas influenced by anthropogenic emissions, while the high and low ends of the distributions of the observed O_3 concentrations are moving toward mid-level values as emissions are reduced, background O_3 concentrations ***increase*** (Lefohn et al., 2014; EPA, 2014a; Dolwick et al., 2015). In other words, background O_3 is not a fixed range of concentrations, but rather background is a varying range of concentrations, whose values ***increase*** as anthropogenic emissions are reduced.

Thus, both emissions-influenced background (EIB) (Lefohn et al. (2014) and U.S. Background (USB_{ab}) (Dolwick et al., 2015; EPA, 2014a) increase as emissions are reduced.

For high-elevation sites in the western U.S. that are not heavily influenced by local or regional anthropogenic emissions, it would not be anticipated that O_3 concentrations would change much as emissions were reduced elsewhere (Lefohn et al., 2014). For example, the EIB O_3 estimates for Yellowstone NP indicate that the background concentrations contribute in general greater than 80% to the observed O_3 concentrations measured. Dolwick et al. (2015) point out that for rural portions of the western U.S., it is not uncommon for high O_3 days (e.g., days in the worst 10 percent for a season) to be affected substantially (e.g., > 70-80%) by U.S. background O_3. The implications are that sites substantially influenced by background are little affected by changes in North American emission reductions from upwind sources.

As indicated earlier, Figs. 1-5 illustrate that background O_3 currently makes up a substantial percentage of the observed O_3 levels under current conditions across the U.S. (Lefohn et al., 2014; EPA, 2014a; Dolwick et al., 2015). As anthropogenic emissions are reduced to attain achieved 75, 70, 65, and 60 ppb levels, background O_3 increases due to less scavenging by NOx (Lefohn et al., 2014; EPA, 2014a,c; Dolwick et al., 2015). EPA (2014b) described the distributions of composite monitor 8-hour daily maximum values for April-October 2007 for 12 urban case study areas used in the epidemiology-based risk assessment (Fig. 7). Plots depict values based on ambient measurements (base), and values obtained with the HDDM adjustment methodology showing attainment of 75, 70, 65 and 60 ppb alternative standards. A further description of the figure can be found in EPA (2014b) on page 4-24. In reviewing Fig. 7, we see for the anthropogenically influenced sites that a large percentage of the 8-hour average daily maximum concentrations occur in the 25-55 ppb range when attainment is achieved at the 75, 70, 65 and 60 ppb levels. As emission reductions occur at the anthropogenically influenced sites, the difference between the lower and higher concentrations becomes smaller. Background O_3 at most of the sites that are illustrated in Fig. 7 is bounded within the 25-55 ppb observed O_3 range and background makes up a large percentage of the hourly average concentrations in this range. For Denver, Colorado, a location whose observed O_3 levels are influenced by stratospheric intrusions (Lefohn et al., 2001; Langford et al., 2009; Lefohn et al., 2014), background O_3 contributes important amounts to the observed O_3 levels above the 25-55 ppb range.

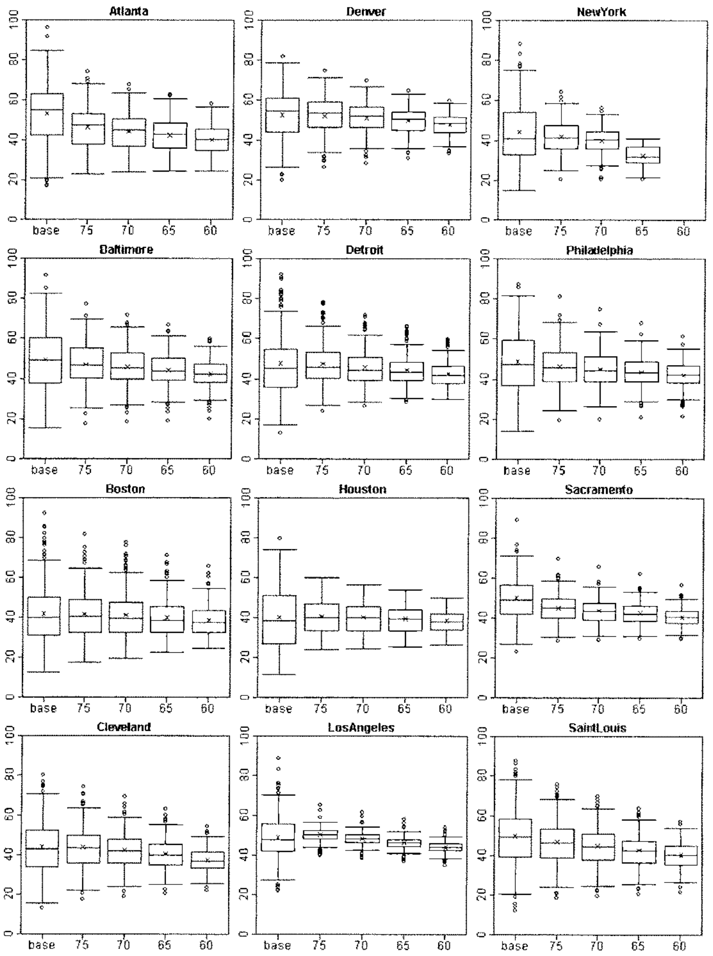

Fig. 7. Distributions of composite monitor 8-hour daily maximum values for April-October 2007 for the 12 urban case study areas in the epidemiology-based risk assessment. Plots depict values based on ambient measurements (base), and values obtained with the HDDM adjustment methodology showing attainment of 75, 70, 65 and 60 ppb standards. Boxes represent the median and quartiles, X's represent mean values, whiskers extend up to 1.5x the inter-quartile range from the boxes, and circles represent outliers. (Source: Fig. 4-9 from EPA (2014b) page 4-24).

5. Anthropogenic Emission Reductions Result in the Highest Observed Concentrations Becoming More Heavily Influenced by Background Ozone

At sites influenced by anthropogenic emissions, the contribution of background O_3 to observed levels is lowest during the summer, when maximum observed concentrations occur. However, when one takes into consideration future reductions of emissions to achieve possible lower standards, this does not mean that background will continue to be unimportant during the summer. Ozone concentrations, consisting of both anthropogenic and background contributions, change their relative importance to one another as emission reductions occur during all times of the year. As emissions are reduced, background O_3 becomes more important in relation to anthropogenically produced concentrations during all seasons (Lefohn et al., 2014; EPA, 2014a).

The EPA notes (Federal Register, 2014: page 75382) that its modeling indicates that U.S. anthropogenic emission sources ***currently*** are the dominant contributor to the majority of O_3 exceedances of the NAAQS at most sites across the U.S. EPA's conclusion is based on results that indicate background contributions at most sites are generally similar on high O_3 days, as well as on all other O_3 days. As a result, under ***current*** conditions the EPA concludes that the proportional influence of background sources tends to be lower on high O_3 days (which in general occur during the summer at anthropogenically perturbed sites). Under ***current*** emission conditions for sites heavily influenced by anthropogenic emissions, Lefohn et al. (2014) report a similar observation. However, as emission reductions occur at anthropogenically influenced sites, the relative importance of background O_3 increases at the highest O_3 concentrations.

Background O_3 has a higher contribution to observed O_3 levels during the spring compared to the summer across the U.S. The growing importance of background O_3 as emissions are reduced to meet lower possible standards is observed in EPA's modeling results. EPA

(2014c) notes that as emissions are reduced to attain lower possible standard levels there will be a higher relative contribution of background O_3 to observed O_3 across the entire U.S. EPA (2014c) notes that the frequency of the highest O_3 concentrations will shift from the summer to the spring. Many non-U.S. anthropogenic sources, such as stratospheric intrusion (Lefohn et al., 2011; Lefohn et al., 2012) and international transport peak during the spring months. According to the EPA (2014c), the shift in season is a result of more O_3 decreases during the summer months compared to other times of the year and more O_3 increases during the winter months due to the lessening of NOx titration on O_3. Besides the highest concentrations, for most cities analyzed, the EPA notes that the highest interquartile (i.e., 25-75 percent) O_3 concentrations under ***current*** conditions occur during the summer months (i.e., June-August). However, for many areas the highest interquartile O_3 concentrations will shift to the spring months (i.e., April-May) as the current 75 and proposed 65 ppb standard levels (EPA, 2014c) are attained. As this shift occurs, background O_3 will contribute important amounts to the observed O_3 concentrations. The dominance of springtime background O_3 concentrations is observed at some National Park sites in the U.S. (EPA, 2014d). As exceedances of the NAAQS occur when lower standard levels are promulgated, background O_3 concentrations at both high- and low-elevation sites will play a more important role in contributing to the exceedances.

EPA (Federal Register, 2014 page 75383) agrees that there is no question that as the levels of alternative prospective standards are lowered, background will represent increasingly larger percentages of total O_3 levels and may subsequently complicate efforts to attain these standards. If lower standard levels were promulgated, background will increase and exceedances will become more common. The Agency contends that its policies allow for the exclusion of air quality monitoring data from design value calculations when they are substantially affected by certain background influences (Federal Register, 2014 page 75242). The EPA cites its work to reduce international transport of O_3 and other pollutants that contribute to background O_3 levels under the Convention on Long-Range Transboundary Air Pollution (LRTAP) of the UN Economic Commission for Europe, as well as other international efforts, leading to reductions of background O_3 (Federal Register, 2014 page 75372).

However, EPA's position on controlling background is not necessarily well established and overlooks the relative importance of the contribution to background O_3 from long-range transport of anthropogenic emissions versus natural stratospheric intrusions (see Appendix B; Lefohn and Oltmans, 2014c). Recent work (Lin et al., 2012a, 2012b; Langford et al., 2014) raises questions as to how effective exceptional event categorization and procedures for establishing such an event will be in excluding air quality monitoring data that fall in the 65-70 ppb MDA8 range, especially at sites in the western U.S. Most of the events that might currently be classified as exceptional events under the current MDA8 standard of 75 ppb or under the proposed stricter standard appear to have a substantial contribution from O_3 with an initial source in the stratosphere (Lefohn et al., 2011; Lefohn et al., 2012; Lefohn et al., 2014; 2015). As noted in Langford et al. (2014) from a recent research field investigation in Clark County, Nevada "exceedances of the NAAQS (for a 65 ppb standard) generated by high background concentrations and stratospheric intrusions would have occurred on 60% of the days during LVOS (Las Vegas Ozone Study), making these events the rule rather than the exception" at their study sites. In the only documented case accepted by the EPA of an exceptional event attributed to substantial stratospheric influence, a document exceeding 100 pages was filed The practicality of submitting 100 page documents each time an exceedance of the standard occurs that is associated with natural stratospheric intrusions is questionable.

Published work (Zhang et al., 2011; Lin et al., 2012a, 2012b; Lefohn et al. 2014) and ongoing research (Fiore et al., 2014; Lefohn et al., 2015) reinforce the important contribution of North American background O_3 (NAB) on 8-hour maximum daily average O_3 (MDA8) at or near current air quality standards. In particular, during the spring and early summer, background O_3 over the western U.S. is routinely elevated. *Elevated background is a persistent feature in the spring and early summer in the western U.S. and is likely not easily identifiable as exceptional events but rather it contributes on a continuous basis as enhancements to surface O_3 concentrations.*

An ongoing evaluation of background O_3 levels in two chemistry transport models, the Geophysical Fluid Dynamics Laboratory (GFDL) AM3 and GEOS-Chem, has shown that these models are able to capture a number of the important features of background O_3 over the U.S. A recent study (Fiore et al., 2014) compared the two models and the authors reported that although both the AM3 and GEOS-Chem models capture a number of the important features of background O_3 over the U.S., important differences occur. For several reasons discussed in Fiore et al. (2014), biases were found over the western U.S. in the spring, with underestimates for GEOS-Chem and overestimates for AM3. The need for adjusting for model biases in both models was noted in the Fiore et al. (2014) paper. Based on recent work (Lefohn et al., 2014; Lefohn et al., 2015), adjustments for biases, primarily associated with the stratospheric contribution to background O_3, found that the two models' attribution of background O_3 was very similar at a number of sites particularly in the U.S. Intermountain West (see Appendix A).

6. Can Background Ozone be Reduced?

Potential strategies, such as international agreements to control emissions contributing to long-range transport of O_3 that produce high background O_3, do not hold up to careful scrutiny. Although two studies (Fiore et al., 2009; Zhang et al., 2011) are cited by CASAC as evidence for justifying the potential effectiveness of controlling international emissions in reducing background O_3 over the U.S., these studies actually produce conflicting results. In particular, the modeling results described in Zhang et al. (2011) attributes a very large contribution of international long-range transport to background O_3 over the U.S. of 9 ppb in spring-summer at low-elevation sites and 13 ppb at high-elevations sites. It is our expert opinion that the high values attributed in Zhang et al. (2011) to international long-range transport are not representative or consistent with other studies reported in the peer-reviewed literature. The Fiore et al. (2009) work reports much lower values for spring and summer over the U.S. In particular, levels closer to 2 ppb for the contribution from East Asian and European emissions over the U.S. are presented. Two published studies by Lin et al. (2012a, 2012b) report that for the period in 2010 of their study, the contribution from Asian pollution to the western US was ~5 ppb. Lin et al. (2012a) estimate that east of the Intermountain West O_3 enhancements from Asian pollution were ~ 2-4 ppb. Lin et al. (2012a) indicate that long-range transport of Asia mostly affects sites in the West and Intermountain West and that the contribution of Asian emissions on surface O_3 is much less than stratospheric O_3 (i.e., approximately 20% of the contribution estimated for stratospheric O_3). Results published in the literature indicate large discrepancies in the attribution of the levels of Asian pollution O_3 to background O_3. These discrepancies are a topic that requires further research. It is unclear what effect international emission reductions would have on surface O_3 concentrations in the U.S. Results published in the peer-reviewed literature indicate that natural stratospheric intrusion enhances surface O_3 4-5 times greater than O_3 associated with the long-range transport from Asia. Therefore, it is unclear if background O_3 could be substantially reduced because of the contribution from uncontrollable, natural sources of O_3. For additional information, please see Appendix B.

7. The Influence of Background Ozone on EPA's Human Health Risk Estimates

The EPA Administrator utilizes controlled human exposure studies and mortality/morbidity and lung-function risk estimates for assessing the health impact of O_3. This information is used to establish the level of the primary standard. The controlled human exposure studies provide the Administrator with an initial consideration for the level at which the health standard could be set. The risk estimates provide further clarification to the Administrator for refining her initial consideration and provides a margin of safety associated with her final decision on the O_3 NAAQS.

As noted in the Federal Register (2014 page 75288), the Administrator places greater weight on information on controlled human exposure studies (i.e., FEV_1 decrement risk analyses) rather than on the epidemiological results (Federal Register, 2014 page 75288). As noted by the Administrator, the epidemiological results did not indicate much risk benefit as the current and proposed standards were estimated to be attained through simulated modeling.

In summarizing its mortality and morbidity epidemiological risk results, on page 9-22 of the Health Risk and Exposure Assessment (HREA) (EPA, 2014b), EPA noted that the epidemiological risks did not show large increases in benefits as emissions were reduced to meet existing or alternative levels of the standard. EPA provided several reasons for this observation. First, the epidemiological risks reflected the impact of changes in O_3 along the complete range of

8-hour average O_3 concentrations (i.e., maximum values all the way down to zero values). In other words, in contrast to the exposure-response function for FEV_1 decremental effects that weighted higher concentrations greater than the mid- and low-level values, the concentration-response function for the epidemiological risk analyses weighted all concentrations the same. Second, as mentioned earlier, EPA's modeling results indicated that the lowest O_3 concentrations ***increased*** and the highest concentrations ***decreased*** as a result of just meeting existing and alternative standards. The result of applying an unweighted concentration-response function for the epidemiological risk resulted in (1) the reduced risk predicted to occur by reducing the highest concentrations being counter balanced by (2) the increased risk predicted to occur as the lower concentrations shifted toward the mid-level values as per EPA's modeling estimates.

Coupled with the lack of increases in risk benefits as emissions were reduced to meet existing or alternative levels of the standard, the mortality and morbidity epidemiological risks were affected by background O_3 levels. The EPA's mortality and morbidity risk estimates for attaining the current and proposed standards are heavily influenced by 8-hour average ambient concentrations in the 25-55 ppb range (EPA, 2014a, 2014b). For epidemiological mortality risk estimates calculated by the EPA using 2007 data (EPA, 2014b), Fig. 8 illustrates that reducing emissions to attain the various standards increased the predicted risk associated with the mid-range concentrations (25-55 ppb). The accumulation of risk in the 25-55 ppm range made up the greatest percentage of the total risk. In some cases, 90% or more of the accumulated risk occurs in the 25-55 ppb range. As indicated earlier, background O_3 contributes a large percentage of the observed O_3 measured concentrations in the 25-55 ppb range across the U.S. (Lefohn et al., 2014). Therefore, the mortality and morbidity risk estimates made by the EPA that were associated with attaining the current, as well as proposed lower standards were heavily influenced by background O_3.

The observed outcome from the epidemiological risk analyses was a result of not taking into consideration the heavy influence of background O_3 in the 25-55 ppb range on the risk estimates. The heat maps presented in Figures 7-2 and 7-3 in the HREA (EPA, 2014b) demonstrate that just meeting progressively lower proposed standard levels narrowed the distribution of epidemiological risk across the range of O_3 concentrations and that the distribution of risk tended to be more centered on concentrations in the range of 25-55 ppb (EPA, 2014b). As EPA concluded on page 9-23 of the HREA (EPA, 2014b), the focus of the epidemiological studies on urban study area-wide average O_3 concentrations, and the lack of thresholds coupled with the linear nature of the concentration-response functions meant that in its analysis, the impact of a peak-based standard like the 8-hour standard (i.e., which seeks to reduce peak concentrations regardless of effects on low or mean concentrations) on estimates of mortality and morbidity risks based on results of those studies was relatively small.

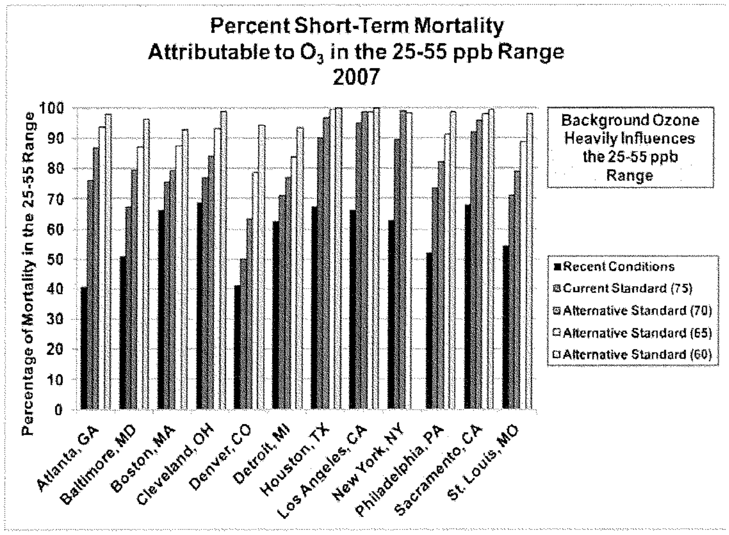

Fig. 8. Percent short-term O_3-attributable mortality in the 25-55 ppb range for various exposure conditions for 2007. (Source: Data from Fig. 7-B1 on page 7-B3 of EPA, 2014e).

As indicated above, the controlled human exposure risk estimates associated with FEV_1 lung function decrements are an important input to the EPA Administrator for assessing the margin of safety associated with establishing the O_3 NAAQS. While information was provided by (EPA, 2014a, 2014b) and Lefohn et al. (2014) that cumulative mortality and morbidly epidemiological risk estimates were heavily influenced by the concentration range 25-55 ppb and therefore, background O_3, no such information was available readily available to determine whether the cumulative lung function risk estimates were also heavily influenced by concentrations in the 25-55 ppb range. We know from EPA's modeling results (EPA, 2014b), as emissions are reduced to attain the proposed standard levels, the higher concentrations will shift downward, while the lower concentrations will shift upward. Both the high and the low concentrations will therefore shift toward the mid-range concentrations (i.e., 25-55 ppb), which are heavily influenced by background O_3 (Lefohn et al, 2014). Therefore, it is important to assess the role that the mid-range concentrations play in the cumulative lung function risk estimates as emissions are reduced.

Gradient, an environmental and risk sciences consulting firm located in Cambridge, MA, and A.S.L. & Associates worked together to explore to what degree the lung function risk estimates were heavily influenced by concentrations in the 25-55 ppb range. Gradient used the Air Pollutants Exposure (APEX) model to estimate children's lung function decrements under various 2007air quality scenarios for Los Angeles, Denver, Houston, Philadelphia, and Boston. For each of the 5 cities, five APEX scenarios (i.e., current, 75 ppb, 70 ppb, 65 ppb, and 60 ppb) were run. The simulations were based on the APEX modeling conducted by the EPA which is described in the HREA (EPA, 2014b), including the use of the threshold version of the McDonnell, Stewart, and Smith (MSS) model to estimate decrements in forced expiratory volume in 1 second (FEV_1). The EPA provided Gradient with the same input files and parameters as the APEX modeling conducted by the EPA for Gradient's model simulations. Further details describing the simulation runs are provided in Appendix C.

Figure 9 summarizes the effect of background O_3 on lung function risk assessments (FEV_1 decrements >10%). This figure focuses on mid-range concentrations for children aged 5-18 based on APEX model output for Los Angeles, Denver, Houston, Philadelphia, and Boston. The estimated risk was summarized in 5 ppb concentration increments (i.e., bins) and the estimated risk was summed over the 25-55 ppb range and divided by the total accumulated estimated risk and then multiplied by 100. This calculation provided the determination of the percentage of the cumulative frequency of responses in the mid-range concentration of 25-55 ppb. For Los Angeles, a large percentage of the cumulative frequency of responses is associated with the 25-55 ppb range for attainment of the 75, 70, 65 and 60 ppb levels. Background O_3 plays an important role in the cumulative risk. The cumulative frequency of responses for daily FEV_1 decrements >10% were 9% (current level), 52% (attaining the 75 ppb level), 65% (attaining the 70 ppb level), 77% (attaining the 65 ppb level), and 91% (attaining the 60 ppb). For the Denver urban study area, a large percentage of the cumulative frequency of responses is also associated with the 25-60 ppb range for attainment of the 75, 70, 65 and 60 ppb levels. The accumulative range for Denver was expanded from the 25-55 ppb to 25-60 ppb because background O_3 at this high-elevation study area is greater than at low-elevation sites. Lefohn et al. (2014) notes that background O_3 contributes approximately 70% to the observed concentration in the 55-60 ppb range (see Fig. 4). The cumulative frequency of responses in the Denver urban area for daily FEV_1 decrements >10% were 33% (current level), 56% (attaining the 75 ppb level), 72% (attaining the 70 ppb level), 87% (attaining the 65 ppb level), and 97% (attaining the 60 ppb). For the Houston area, a large percentage of the cumulative frequency of responses is associated with the 25-55 ppb range for attainment of the 75, 70, 65 and 60 ppb levels. The cumulative frequency of responses in the Houston urban area for daily FEV_1 decrements >10% were 12% (current level), 49% (attaining the 75 ppb level), 64% (attaining the 70 ppb level), 80% (attaining the 65 ppb level), and 95% (attaining the 60 ppb). While the concentrations in the 25-55 ppb range played less of a role in the cumulative lung function risk analysis for Philadelphia and Boston than for the other 3 cities, a great deal of the accumulated risk was associated with the 25-65 ppb range, especially for the 65 ppb and 60 ppb scenarios. For Philadelphia, the cumulative frequency of responses for daily FEV_1 decrements >10% associated with the 25-55 ppb range were 5%, (current level), 20% (attaining the 75 ppb level), 32% (attaining the 70 ppb level), 51% (attaining the 65 ppb level), and 73% (attaining the 60 ppb).

For Boston, the cumulative frequency of responses associated with the 25-55 ppb range were 6% (current level), 13% (attaining the 75 ppb level), 18% (attaining the 70 ppb level), 32% (attaining the 65 ppb level), and 53% (attaining the 60 ppb).

Similar to the morbidity and mortality health risk estimates that are heavily influenced by background O_3 in the 25-55 ppb range, the cumulative lung-function risk estimates for Los Angeles, Denver, and Houston also appear to be heavily influenced by background concentrations.

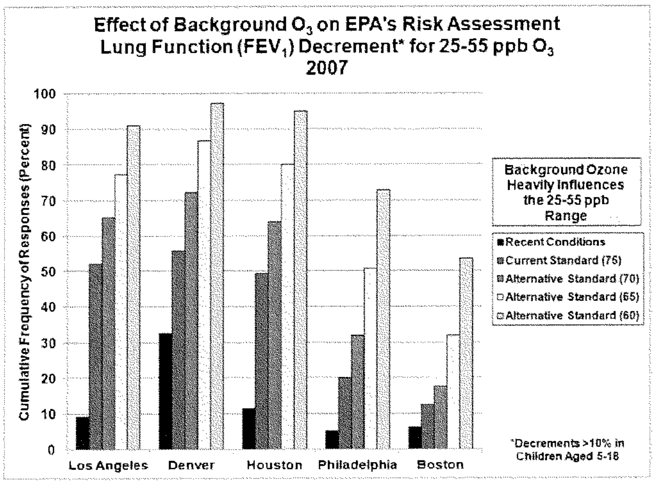

Fig. 9. The percentage of the cumulative frequency of responses in children aged 5-18 associated with the 25-55 ppb range for the Los Angeles, Denver, Houston, Philadelphia, and Boston urban study areas using EPA's APEX model.

8. Conclusion

The information that the Agency has provided allows one to assess the relative contribution of (1) anthropogenic O_3 and (2) background O_3 to its human health risk estimates. As noted in the HREA (EPA, 2014b), the epidemiological risk estimates for attaining the 75, 70, 65 and 60 ppb standards indicate that a large percentage of the risks are associated with 8-hour average ambient concentrations in the 25-55 ppb range, which is heavily influenced by background O_3. Our analyses for the Los Angeles, Denver, and Houston urban study areas indicate that the lung function risk estimates are heavily influenced by the concentration range 25-55 ppb range and therefore background O_3.

Based on information published in the literature and by EPA (2014a,b,c,d,e,f), we conclude the following:

- As emissions are reduced, background will contribute more to observed exceedances of the standard;
- The range of concentrations between the highest and lowest will narrow and the number of mid-range concentrations (i.e., 25 – 55 ppb) will increase as emissions are reduced;
- The large contribution of background in the mid-range will grow as proposed standards become more stringent;
- As emissions are reduced, EPA's mortality and morbidity health risk will be heavily influenced by background O_3;
- As emissions are reduced, EPA's lung function risk estimates appear to be heavily influenced by background O_3 in some cities; and
- The margin of safety determination that the Administrator applies in establishing the level of the NAAQS O_3 health standard is influenced by background O_3.

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Appendix A

Identifying the Range of Concentrations When Background Ozone is Important

The 25-55 ppb concentration range has been highlighted in the EPA's Health Risk and Exposure Assessment (HREA) (EPA, 2014b) and Policy Assessment (PA) documents (EPA, 2014a). As anthropogenic emissions are reduced, the frequency of concentrations in this mid-level concentration range increases with the result that a large percentage of the total risks is associated with these concentrations as the current and possible proposed standard levels are achieved.

Using the Higher-order Decoupled Direct Method (HDDM) model, EPA estimated changes for 12 urban case study areas in 8-hour daily maximum concentrations that would occur as emissions were reduced. These changing O_3 concentration distributions were inputted into the epidemiology-based risk assessment (EPA, 2014b). Figure A-1 depicts plots of the distribution of concentration levels whose values are based on ambient measurements (i.e., base), and values obtained with the HDDM adjustment methodology showing attainment of 75, 70, 65 and 60 ppb standards. Boxes represent the median and quartiles, X's represent mean values, whiskers extend up to 1.5x the inter-quartile range from the boxes, and circles represent the outliers. In general, as EPA applied its HDDM model, the range (i.e., difference between the top and bottom of the distributions) of the composite monitor concentrations decreased (i.e., the minimum value increased, while the maximum value decreased) in all 12 urban study areas as the air quality data were adjusted to meet lower standard levels. As illustrated in Fig. A-1, as anthropogenic emissions are reduced to attain the 75, 70, 65, and 60 ppb levels, the high and low ends of the total O_3 concentration distribution shift toward the mid-level values. The pattern associated with the EPA-predicted response of the O_3 distribution of concentrations using the HDDM modeling has been observed at O_3 monitors across the U.S. (Lefohn et al., 1998; Oltmans et al., 2006; Lefohn et al., 2008; Oltmans et al., 2008; Lefohn et al., 2010; Oltmans et al., 2013).

Figure A-1 illustrates for low-elevation sites that as greater emission reductions occur to attain the base (i.e., current), 70, 65, and 60 ppb standard levels, the distributions within each city shift toward a narrower range of concentrations compared to the base conditions. More than half of the 8-hour maximum daily average concentrations is in the 25-55 ppb range (i.e., mid-level values). Contained within this narrow range is background O_3. Lefohn et al. (2014) has reported that Emission-Influenced Background (EIB) O_3 makes up a large percentage of the observed concentrations within the 25-55 ppb range for sites across the entire U.S. As emissions are reduced in areas affected by anthropogenic emissions, the large percentage of background O_3 contribution in this range of concentrations will increase (Lefohn et al., 2014). For high-elevation sites in the western U.S. that are not heavily influenced by anthropogenic emissions, background O_3 concentrations will remain at similar levels as emissions are reduced elsewhere (Lefohn et al., 2014). For example, Fig. A-2 illustrates that Emission-Influenced Background (EIB) O_3 estimates for Yellowstone NP (Lefohn et al., 2014) contribute in general greater than 80% to the observed O_3 concentrations measured across the entire distribution of hourly average O_3 concentrations. The figure illustrates the modeled contributions of hourly EIB to the total O_3 frequency distribution (black curve). The blue and red bars in the figure show the relative contribution, within each concentration bin, of background O_3 compared to anthropogenic sources, respectively.

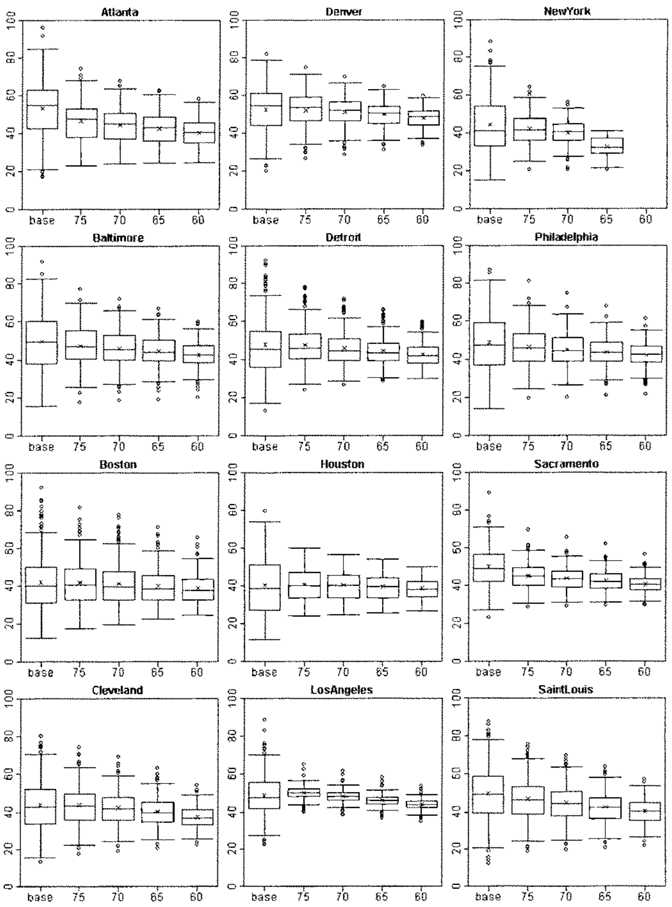


Fig. A-1. Distributions of composite monitor 8-hour daily maximum values for the 12 urban case study areas in the epidemiology-based risk assessment. Plots depict values based on ambient measurements (base), and values obtained with the HDDM adjustment methodology showing attainment of 75, 70, 65 and 60 ppb standards. Values shown are based on CBSAs for April-October of 2007. Note that the HDDM 8 adjustment technique was not able to adjust air quality to show attainment of a 60 ppb standard in New York, so no boxplot is shown for that case. Boxes represent the median and quartiles, X's represent mean values, whiskers extend up to 1.5x the inter-quartile range from the boxes, and circles represent outliers. (Source: Fig. 4-9 of HREA page 4-24).

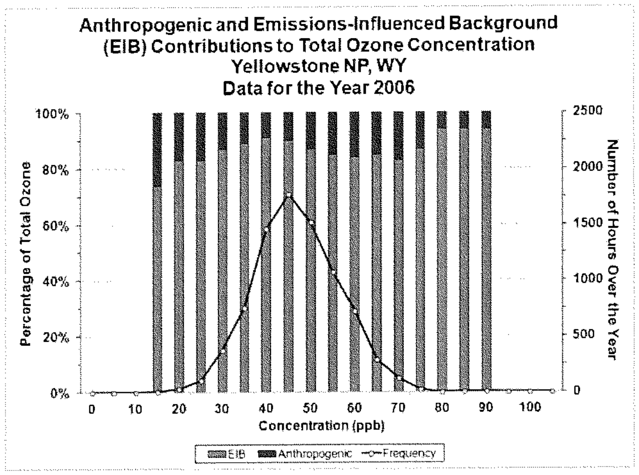


Fig. A-2. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB (blue) and anthropogenic (red) O_3 (bars; left axis) for ambient conditions in 2006 at Yellowstone NP, Wyoming. (Source: Lefohn et al., 2014).

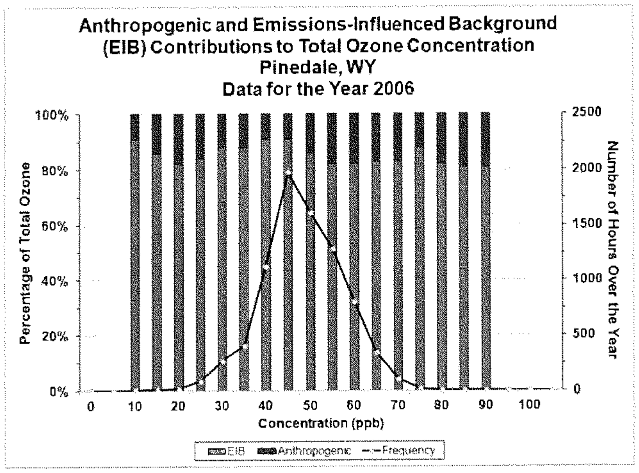


Fig. A-3. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB (blue) and anthropogenic (red) O_3 (bars; left axis) for ambient conditions in 2006 at Pinedale, Wyoming. (Source: Lefohn et al., 2014).

Figure A-3 illustrates the percentage contribution of background to observed O_3 for the site at Pinedale, Wyoming. The blue and red bars in the figure show the relative contribution, within each concentration bin, of background O_3 compared to anthropogenic sources, respectively. Similar to the results for Yellowstone NP, Pinedale is heavily influenced across all hourly average concentrations by background O_3. Dolwick et al. (2015) point out that for rural portions of the western U.S., it is not uncommon for high O_3 days (e.g., days in the worst 10 percent for a season) to be affected substantially (e.g., > 70-80%) by U.S. background O_3. Figures A-2 and A-3 indicate that Yellowstone NP and Pinedale are strongly influenced by background and are not anticipated to be affected much by changes in North American emission reductions from upwind sources. Zhang et al. (2014) note that sites such as Yellowstone NP and Pinedale would not be expected to be influenced much by California anthropogenic O_3 concentrations.

Because both Yellowstone NP and Pinedale, sites located in the Intermountain West, are heavily influenced by background O_3, we investigated the variability of background O_3 across years (2006 and 2010) for the two sites for the April-June period. Comparing results from Lefohn et al. (2014) with those from Lefohn et al. (2015), we find little difference across years for either of the two sits using estimates of adjusted 8-hour background O_3 levels derived from different models. Although the Emissions-Influenced Background O_3 levels derived from the GEOS-Chem/CAMx for April-June 2006 (Lefohn et al., 2014) are derived using a different methodology than the adjusted North American Background (NAB) O_3 values derived from the Geophysical Fluid Dynamics Laboratory (GFDL) AM3 model (Lin et al., 2012b) for April-June 2010, the results are similar (Figs. A-4 and A-5). While day-to-day variability was different each year, as expected from the differing meteorology, for the Yellowstone and Pinedale sites, background O_3 generally varied over the April-June period within the range of 30-70 ppb.

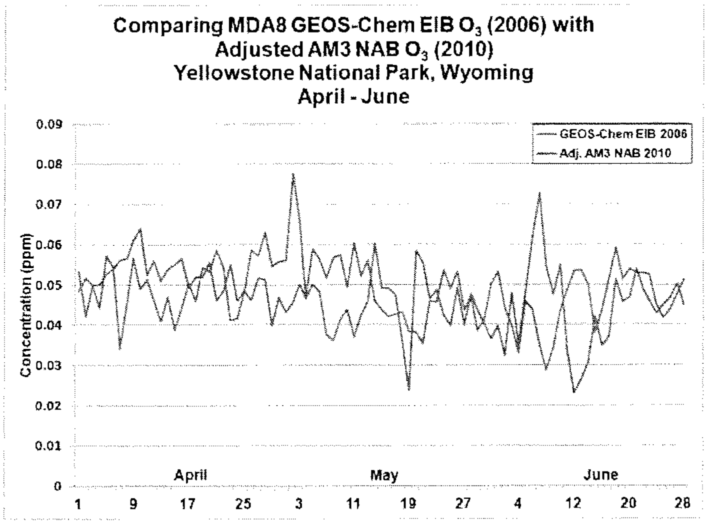


Fig. A-4. Comparing MDA8 GEOS-Chem EIB O_3 (2006) with adjusted AM3 NAB O_3 (2010) for Yellowstone NP for April-June. (Source: Lefohn et al., 2015).

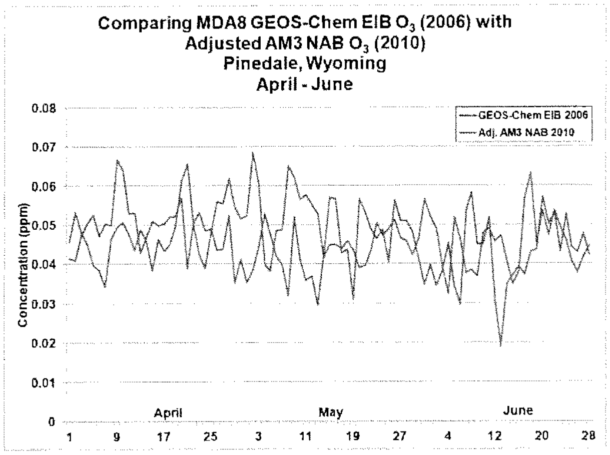


Fig. A-5. Comparing MDA8 GEOS-Chem EIB O_3 (2006) with adjusted AM3 NAB O_3 (2010) for Pinedale for April-June. (Source: Lefohn et al., 2015).

Background O_3 (i.e., EIB O_3) contributes a major portion to estimated total O_3 at most of the high- and low-elevation sites analyzed by Lefohn et al. (2014), especially during the spring. At the western high-elevation sites not heavily influenced by anthropogenic emissions, the contributions of EIB O_3 to total O_3 were usually greater than 70% over the entire year. For the Denver site, a site influenced by anthropogenic emissions, Lefohn et al. (2014) reported that EIB O_3 contributed more than 50% across the concentration distribution (Fig. A-6). Within the 25-55 ppb range, EIB O_3 contributed approximately75 to 80% to the observed O_3. An important observation is that for Denver the range 25-60 ppb shows large contributions from background O_3 to observed O_3 concentrations occur because background O_3 is greater at high-elevation compared to low-elevation sites. Lefohn et al. (2014) notes that background O_3 contributes approximately 70% to the observed concentration in the 55-60 ppb range (see Fig. A-6). The effect of anthropogenic emissions at the Denver site can be observed in Fig. A-6. At the higher concentrations, background O_3 contributed approximately 50%. However, as emissions are reduced to attain current and possible proposed standard levels, background O_3 would be anticipated to increase its contribution to total observed O_3 in the mid-range (i.e., 25-55 ppb), as well as the higher concentrations in the distribution.

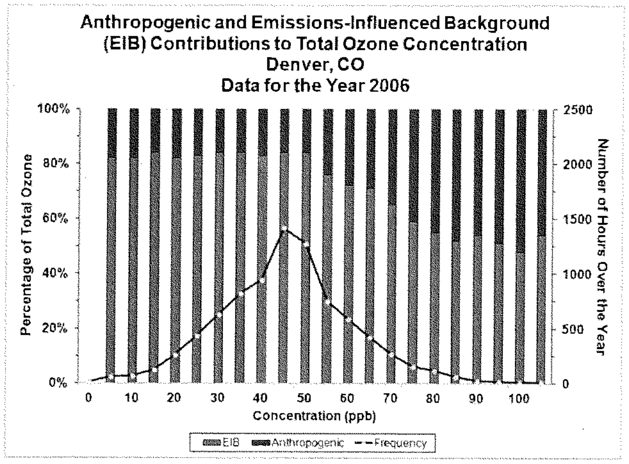


Fig. A-6. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB (blue) and anthropogenic (red) O_3 (bars; left axis) for ambient conditions in 2006 at Denver, Colorado. (Source: Lefohn et al., 2014).

As indicated earlier, the 25-55 ppb concentration range plays an important role in the cumulative health risk estimates. For many of the low-elevation sites, the contributions of background O_3 were 50% and higher (see figures at end of Appendix A). Figures A-7 and A-8 illustrate the percent contribution of background O_3 to observed O_3 for the anthropogenically influenced sites at Los Angeles and Houston. The two sites show the heavy influence of anthropogenic emissions on the highest concentrations (i.e., red bars). However, the Los Angeles site shows 60-80% contribution of background O_3 in the 25-55 ppb range and 55-75% for the

Houston site. As indicated for Denver, as emissions are reduced to attain current and possible proposed standard levels, background O_3 would be anticipated to increase its contribution to total observed O_3 in the mid-range (i.e., 25-55 ppb). As indicated in Appendix C, the background influenced mid-range concentrations have an important impact on the human health risk estimates. Figures from Lefohn et al. (2014) illustrating the percent of background O_3 in relation to observed O_3 across all hourly average concentration levels are presented at the end of this Appendix for Atlanta Baltimore, Boston, Chicago, Cleveland, Dallas, Denver, Detroit, Houston, Los Angeles, New York, Philadelphia, Sacramento, Seattle, St. Louis, Washington DC, Georgia Station, Gothic, Pinedale, Shenandoah NP, Voyageurs NP, Yellowstone NP, and Yosemite NP.

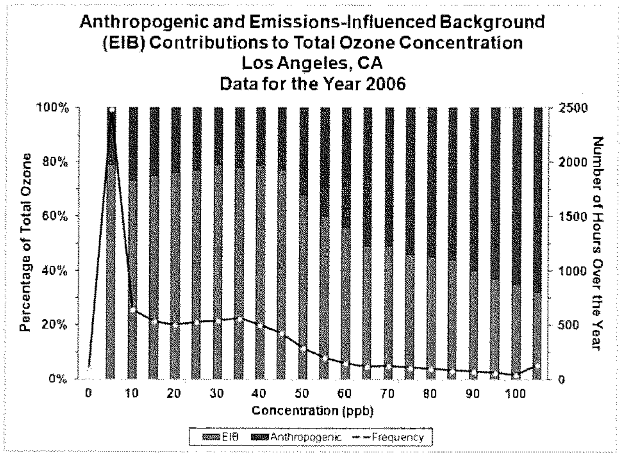


Fig. A-7. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB (blue) and anthropogenic (red) O_3 (bars; left axis) for ambient conditions in 2006 at Los Angeles, California. (Source: Lefohn et al., 2014).

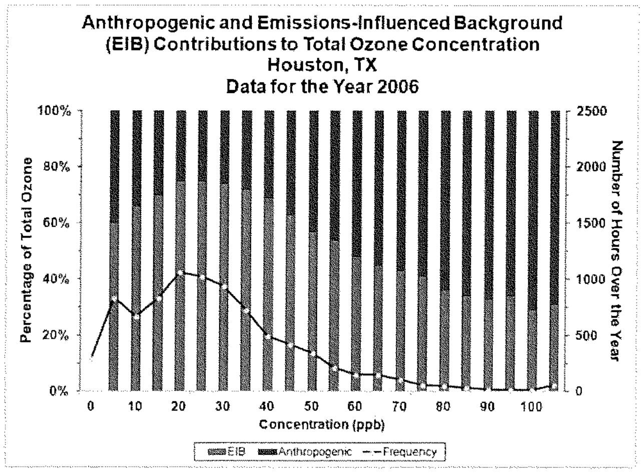
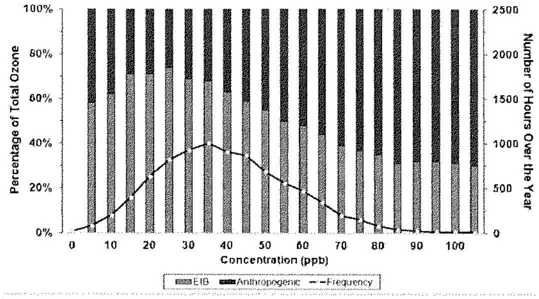
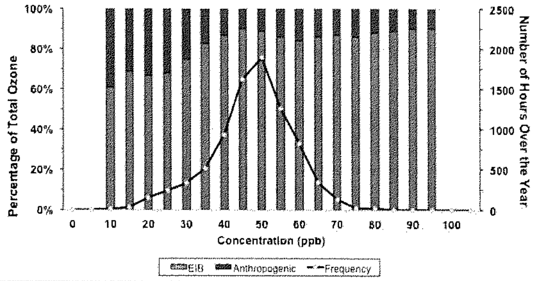


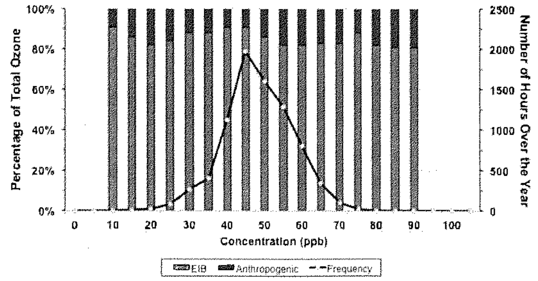
Fig. A-8. Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB (blue) and anthropogenic (red) O_3 (bars; left axis) for ambient conditions in 2006 at Houston, Texas. (Source: Lefohn et al., 2014).



Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration Georgia Station, GA Data for the Year 2006



Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration Gothic, CO Data for the Year 2006



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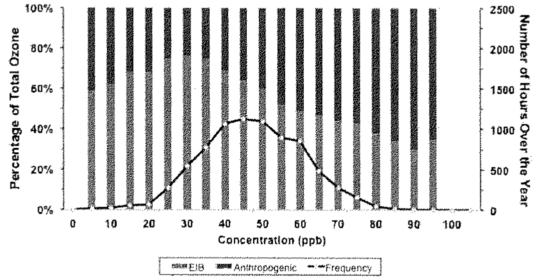
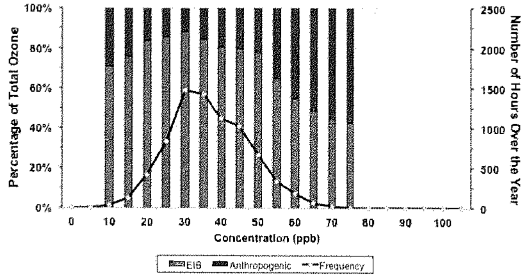


Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration Shenandoah NP, VA Data for the Year 2006

Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration
Voyageurs NP, MN
Data for the Year 2006



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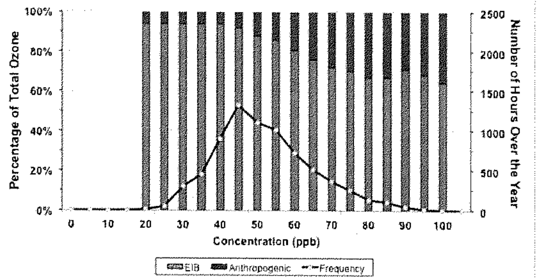
Yosemite NP, CA
Data for the Year 2006



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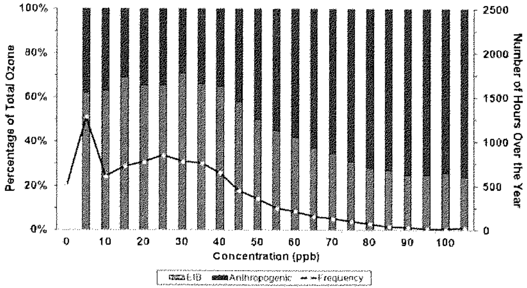
Baltimore, MD
Data for the Year 2006



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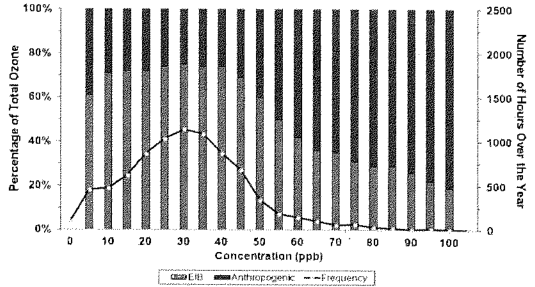
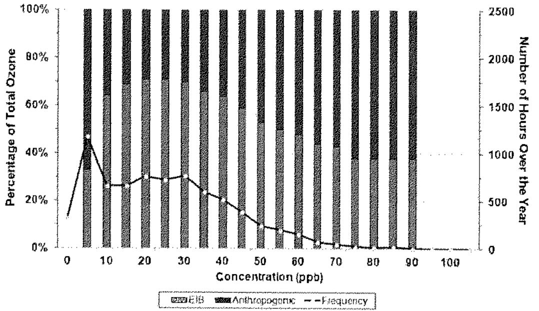
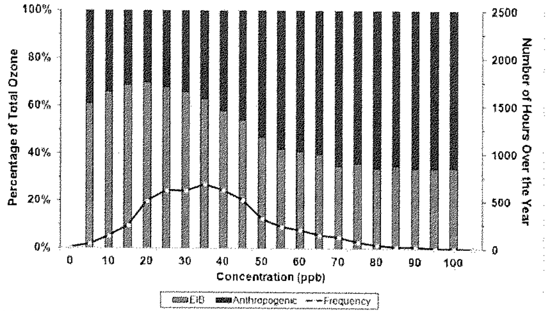
Boston, MA
Data for the Year 2006



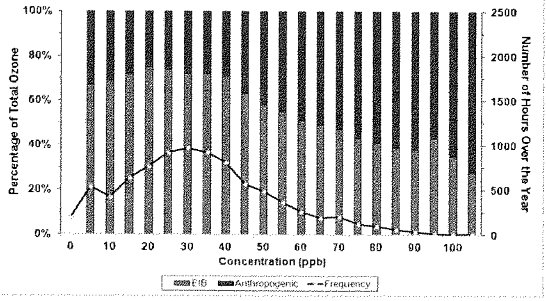
Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration
Chicago, IL
Data for the Year 2006



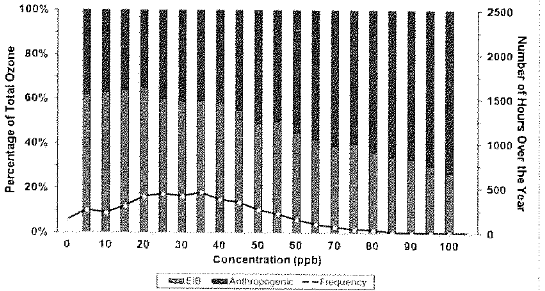
Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration
Cleveland, OH
Data for the Year 2006

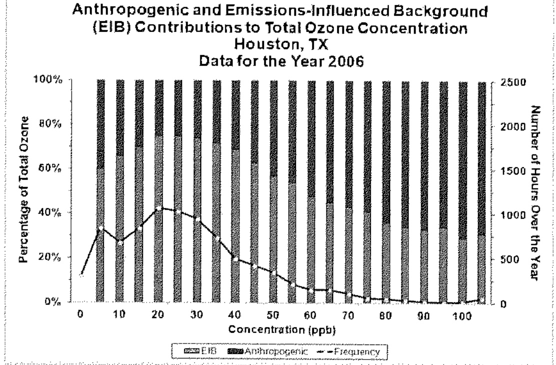


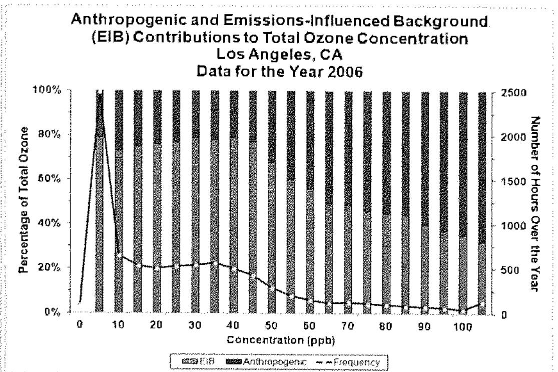
Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration
Dallas, TX
Data for the Year 2006

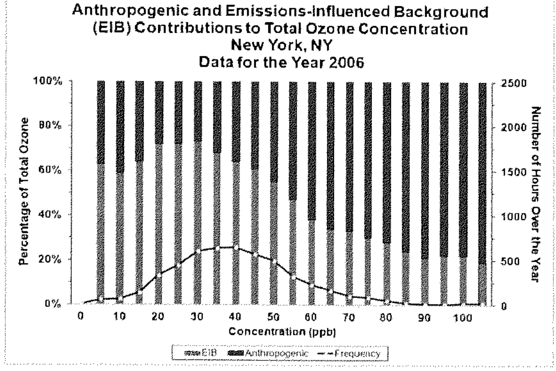


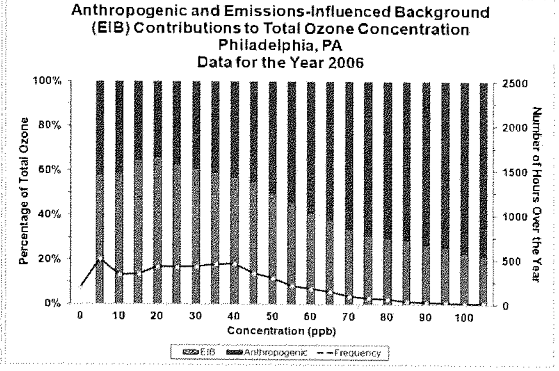
Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration
Detroit, MI
For the Year 2006



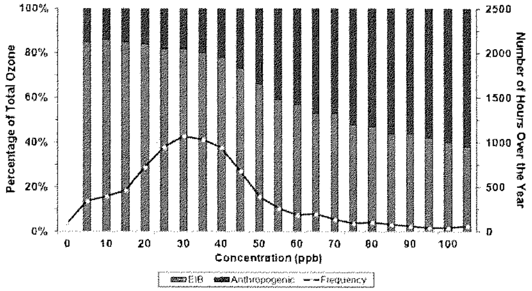

Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration
Houston, TX
Data for the Year 2006
Percentage of Total Ozone
0%
20%
40%
60%
80%
100%
Number of Hours Over the Year
0
500
1000
1500
2000
2500
0
10
20
30
40
50
60
70
80
90
100
Concentration (ppb)
EIB
Anthropogenic
Frequency


Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration
Los Angeles, CA
Data for the Year 2006
Percentage of Total Ozone
0%
20%
40%
60%
80%
100%
Number of Hours Over the Year
0
500
1000
1500
2000
2500
0
10
20
30
40
50
60
70
80
90
100
Concentration (ppb)
EIB
Anthropogenic
Frequency

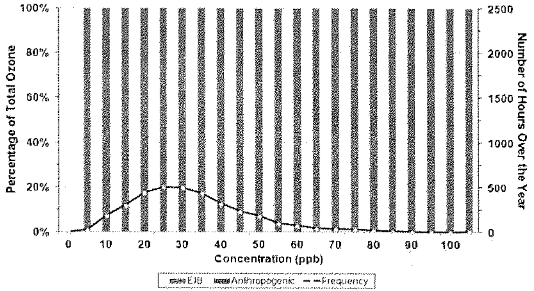

Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration
New York, NY
Data for the Year 2006
Percentage of Total Ozone
0%
20%
40%
60%
80%
100%
Number of Hours Over the Year
0
500
1000
1500
2000
2500
0
10
20
30
40
50
60
70
80
90
100
Concentration (ppb)
EIB
Anthropogenic
Frequency


Anthropogenic and Emissions-Influenced Background (EIB) Contributions to Total Ozone Concentration
Philadelphia, PA
Data for the Year 2006
Percentage of Total Ozone
0%
20%
40%
60%
80%
100%
Number of Hours Over the Year
0
500
1000
1500
2000
2500
0
10
20
30
40
50
60
70
80
90
100
Concentration (ppb)
EIB
Anthropogenic
Frequency

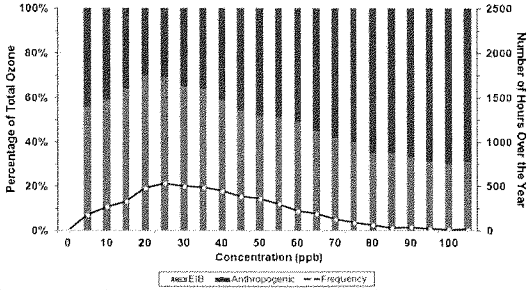
Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Sacramento, CA
Data for the Year 2006



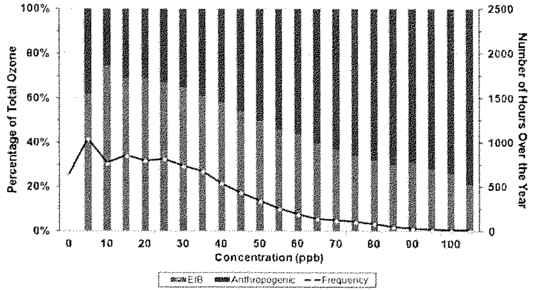
Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Seattle, WA
Data for the Year 2006

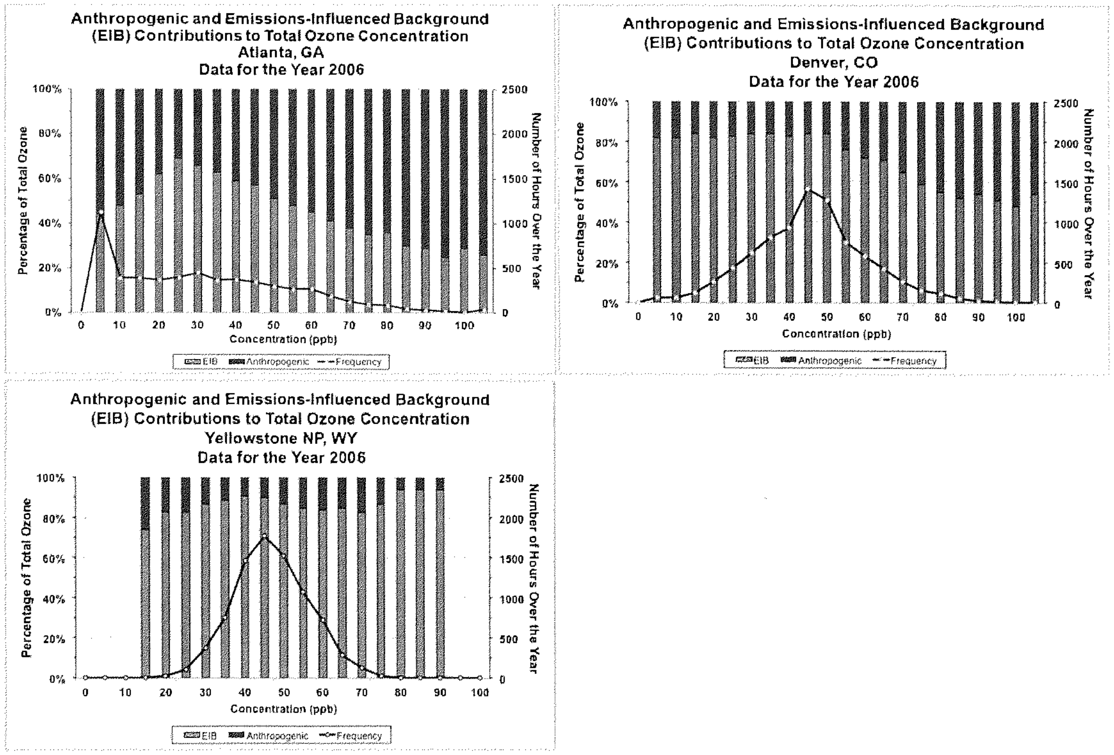


Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
St. Louis, MO
Data for the Year 2006



Anthropogenic and Emissions-Influenced Background
(EIB) Contributions to Total Ozone Concentration
Washington, DC
Data for the Year 2006





Binned (5 ppb) frequency distribution of observed hourly total O_3 (black curve; right axis) and average relative binned contributions of hourly EIB (blue) and anthropogenic (red) O_3 (bars; left axis) for all other sites analyzed. (Souree: Lefohn et al. (2014).

Appendix B

The Relative Importance of Stratospheric Intrusion Processes Versus Long-Range Transport from Asia

The Administrator has implied that background O_3 might be substantially reduced if long-range transport from Asia were reduced through international cooperation (Federal Register, 2014). The implication is that one understands the relative role of anthropogenic long-range transport versus natural processes, such as stratospheric intrusions, on background O_3. Such is not the case.

The modeling results described in Zhang et al. (2011) attributes a very large contribution of international long-range transport to background O_3 over the U.S. of 9 ppb in spring-summer at low-elevation sites and 13 ppb at high-elevations sites. However, the high values attributed in Zhang et al. (2011) to international long-range transport are not representative or consistent with other studies reported in the peer-reviewed literature. Fiore et al. (2009) report much lower values for spring and summer over the U.S. (Fig. B-1). In particular, levels closer to 2 ppb for the contribution from East Asian and European emissions over the U.S. are presented. Lin et al. (2012a, 2012b) report that for the period in 2010 of their study, the contribution from Asian pollution to the western US was ~5 ppb (Fig. B-2 and Table B-1 from Lin et al., 2012b). Lin et al. (2012a) estimate east of the Intermountain West that O_3 enhancements from Asian pollution were ~ 2-4 ppb. Lin et al. (2012a) indicate that long-range transport of Asia mostly affects sites in the West and Intermountain West and that the contribution of Asian emissions on surface O_3 is much less than stratospheric O_3 (i.e., approximately 20% of the contribution estimated for stratospheric O_3) (Table 2 from Lin et al., 2012b).

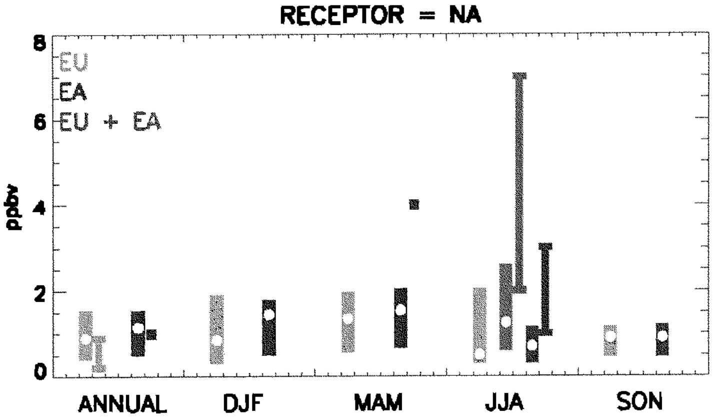


Fig B-1. Annual and seasonal mean contribution to total surface O_3 from foreign source regions as estimated from the individual model results in this study (colored by source region: green for EU, blue for EA, gray for EA + EU, and red for NA) and from studies in the published literature (thin vertical bars for ranges across studies and regions; squares where one value is reported; note that regional definitions, methods for source attribution, and reported metrics (e.g., 24-h versus afternoon versus daytime mean) vary across studies). (Source: Fiore et al., 2009).

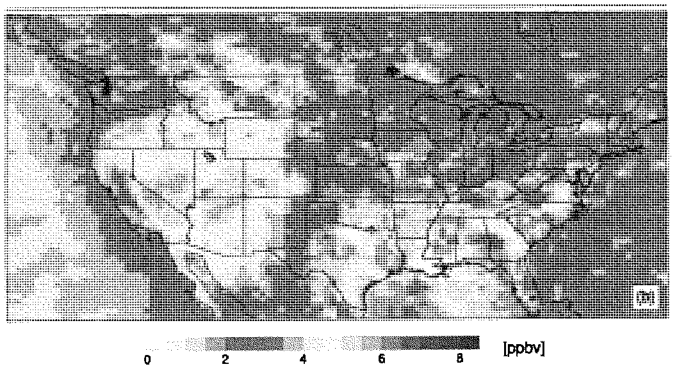


Fig. B-2. Asian pollution enhancements to daily maximum 8-hour ozone in surface air for May–June 2010, estimated with ~50 km AM3. (Source: Lin et al., 2012a).

Table B-1. Surface MDA8 ozone concentrations (in ppbv) averaged over 15 high-elevation western U.S. sites for April-June 2010.

Sources	Mean	Mean for Days > 60 ppbv
Total observed	55.3 ± 8.3	65.1 ± 4.4
Total modeled	61.0 ± 8.6	66.0 ± 8.3
NA anthropogenic	11.0 ± 5.0	11.6 ± 5.3
Total background[a]	50.0 ± 10.6	54.5 ± 10.6
Asian anthropogenic[b]	4.7 ± 2.4	5.3 ± 2.6
Stratospheric	22.3 ± 11.5	25.4 ± 12.3

[a] Includes the contribution from Asian pollution and stratospheric O_3.
[b] Based on AM3 simulations as described by *Lin et al.* [2012].

Source: Lin et al. (2012b).

Lefohn et al. (2014a) reported for the GEOS-Chem/CAMx model that many of the sites across the US, during the spring, fall, and winter months, experienced global background O_3 contributions associated with frequent stratospheric enhancements. In many cases, Lefohn et al. (2014) reported that the GEOS-Chem/CAMx model underestimated total O_3 concentrations and that these underestimates appeared to be associated with the model's underestimates of the importance of stratospheric O_3. For the GFDL AM3 model, Lefohn et al. (2015) found that the adjusted daily stratospheric MDA8 O_3 concentrations substantially contributed to surface O_3 at the high-elevation sites in the West and Intermountain West. Langford et al. (2009; 2014) described the importance of stratospheric O_3 affecting surface O_3 concentrations at western sites.

Results published in the literature indicate large discrepancies in the attribution of the levels of Asian pollution O_3 to background O_3. Clearly, these discrepancies are a topic that requires further research. At this time, based on research published in the peer-reviewed literature, it is unclear what effect international emission reductions would have on surface O_3

concentrations in the U.S. Results from Lin et al. (2012b) indicate that stratospheric intrusion enhances surface O_3 4-5 times greater than O_3 associated with the long-range transport from Asia. Thus, even if international cooperation as suggested by the EPA Administrator could be achieved on Asian emissions reductions, it is unclear if background O_3 would be substantially reduced because of the important contributions associated with uncontrollable, natural stratospheric intrusions.

Appendix C

How Background Ozone Influences EPA's Human Health Risk Outcomes

The EPA Administrator utilizes controlled human exposure studies and mortality/morbidity and lung-function risk estimates for assessing the health impact of O_3. This information is used to establish the level of the primary standard. The controlled human exposure studies provide the Administrator with an initial consideration for the level at which the health standard should be set. The risk estimates provide further clarification to the Administrator for refining her initial consideration and provides a margin of safety associated with her final decision on the O_3 NAAQS. The mid-range concentrations currently observed across the U.S., which are heavily influenced by background, play an important role in the human health risk estimates. As O_3 precursor emissions are reduced to meet more stringent standards, EPA (2014b) notes that O_3 concentrations in the mid-range will occur more frequently and therefore, play even a more important role in the risk estimates.

Risk characterization is the process of communicating the results of risk (and exposure) modeling in terms (i.e., metrics) that decision makers can understand. In the HREA (EPA, 2014b), EPA notes that this translates into providing metrics that are most useful to assess the adequacy of the existing O_3 standards in protecting public health with an adequate margin of safety and to evaluate the additional protection provided by potential proposed standards. The EPA notes in the HREA (EPA, 2014b) and the Policy Assessment document (EPA, 2014a) that the Agency has selected aggregate risk metrics, including the number and percent of vulnerable populations experiencing adverse respiratory responses based on application of results of controlled human exposure studies and the attributable incidence and percent of baseline incidence of mortality and morbidity endpoints based on application of results of epidemiology studies.

As noted by the EPA in the HREA (page 9-30) in summarizing its risk results, many of the differences in the risk results across the metrics used to quantify risk were driven by how each metric was affected by the O_3 concentration data input to the individual analysis. EPA noted that in general, the impact of the HDDM adjustments to O_3 varied based on three main considerations: 1) the degree to which the exposure or risk metric was sensitive to changes across the various ranges of O_3 concentrations (e.g., high, mid-range, low); 2) whether the exposure or risk metric used individual census tract concentrations or area-wide average concentrations; and 3) changes in the distribution of O_3 concentrations in the year of analysis between recent O_3 concentrations and adjusted (i.e., meeting the existing or alternative standards) O_3 scenarios.

One of the important key elements associated with the risk estimates is the change in the distribution of O_3 concentrations between recent O_3 concentrations and adjusted O_3 scenarios. With respect to the changes in the distribution of O_3 concentrations as a function of emission reductions, the risk metrics used in the HREA (EPA, 2014b) were influenced by how the distribution of O_3 concentrations change. The change in the distribution of hourly average O_3 concentrations results from emission reductions to meet current or alternative standard scenarios. The emissions reductions change the O_3 concentrations in the high-, mid-, and low-range parts of the distribution. A way to provide information on the pattern of changes is by characterizing the distribution of hourly average concentrations as higher hourly average O_3 concentrations are reduced as a result of lowering NO_x emissions.

As noted above, the change in the distribution of O_3 concentrations results from emission reductions. The shifts in distribution affect both estimated lung function and epidemiological risks. ***On page 9-22 of the HREA, EPA summarized its mortality and morbidity risks by observing that generally these risks did not show large responses to meeting existing or alternative levels of the standard for several reasons.***

- First, these risks were based on concentration-response functions that were approximately linear along the full range of concentrations, and therefore reflected the impact of changes in O_3 along the complete range of 8-hour average O_3 concentrations. This included days with ***low O_3 concentrations*** that were predicted to have ***increases*** in O_3 concentrations, as well as days with ***higher starting O_3 concentrations that were predicted to have decreases in O_3 concentrations*** as a result of just meeting existing and alternative standards.

- Second, these risks, according to the EPA, reflected changes in the urban-area wide monitor average, which would not be as responsive to air quality adjustments as the design value monitor, and which included monitors with both decreases and increases in 8-hour concentrations.

- ***Third, the days and locations with predicted increases in O_3 concentrations (i.e., generally those with low to midrange starting O_3 concentrations) resulting from just meeting the existing or alternative standard levels generally were frequent enough to offset days and locations with predicted decreases in O_3.*** The heat maps presented in Figures 7-2 (page 7-55) and 7-3 (pager 7-56) in the HREA demonstrated that just meeting progressively lower alternative standard levels narrowed the distribution of risk across the range of O_3 concentrations. In addition, ***the distribution of risk tended to be more centered on area-wide average concentrations in the range of 25 to 55 ppb after just meeting an alternative standard of 60 ppb. The focus of the epidemiological studies on urban case study area-wide average O_3 concentrations, and the lack of thresholds coupled with the linear nature of the concentration-response functions meant that in this analysis, the impact of a peak-based standard (which seeks to reduce peak concentrations regardless of effects on low or mean concentrations) on estimates of mortality and morbidity risks based on results of those studies was relatively small.***

As indicated in the third bullet, the distribution of risk tended to be centered in the 25-55 ppb range of 8-hour daily maximum concentrations after just meeting an alternative standard of 60 ppb. Further investigating the data in Fig. 7-B1 in the HREA Appendix for Chapters 7-9

(EPA, 2014e) on page 7B-3, the greatest percentage of risk tended to also be in the 25-55 ppb range for recent conditions (2007), current standard (75 ppb), proposed standard (70 ppb), proposed standard (65 ppb), and alternative standard (60 ppb). Figure C-1 illustrates that reducing emissions to attain the various standards increased the risk in the 25-55 ppb mid-range concentrations from the current conditions and this range of concentrations make up the greatest percentage of the risk. In some cases, 90% or more of the accumulated risk occurs in the 25-55 ppb range. As indicated earlier, background O_3 contributes a large percentage of the observed O_3 measured concentrations in the 25-55 ppb range across the U.S. (Lefohn et al., 2014). Therefore, the mortality and morbidity risk estimates made by the EPA that were associated with attaining the current, as well as proposed lower standards were heavily influenced by background O_3. ***The observed outcome from the epidemiological risk analyses was a result of accumulating risk over all concentrations, including the heavy influenced background O_3 concentrations in the 25-55 ppb range.***

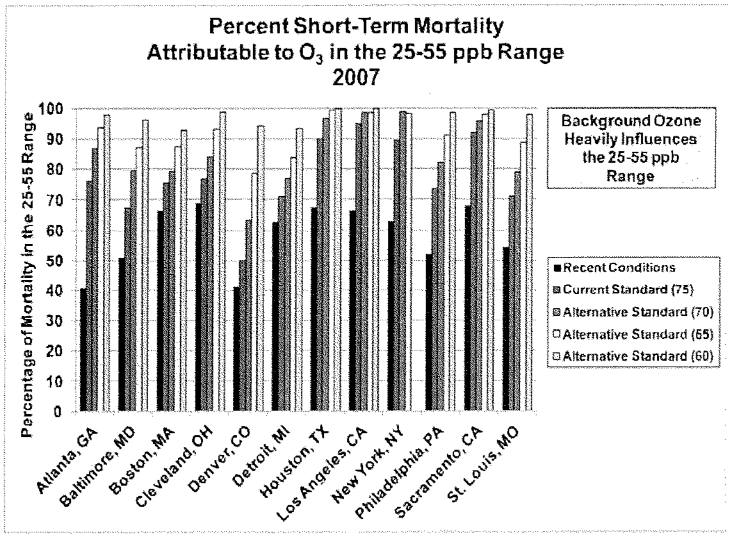


Fig. C-1. Percent short-term O_3-attributable mortality in the 25-55 ppb range for various exposure conditions for 2007. (Source: Data from Fig. 7-B1 on page 7-B3 of EPA, 2014e).

As noted in the Federal Register (2014 page 75288), the Administrator places greater weight on information from controlled human exposure studies (i.e., FEV_1 decrement risk analyses) rather than on the epidemiological results (Federal Register, 2014 page 75288). The Administrator notes that the interpretation of the controlled human exposure study results is not complicated by the presence of co-occurring pollutants or pollutant mixtures (as is the case in epidemiologic studies). Therefore, she focused her attention on information from the controlled human exposure studies. As indicated previously, the epidemiological results were heavily influenced by background O_3 and did not indicate much benefit as concentrations were reduced by simulated modeling.

While information was provided by (EPA, 2014a, 2014b) and Lefohn et al. (2014) that cumulative mortality and morbidly epidemiological risk estimates were heavily influenced by the concentration range 25-55 ppb and therefore, background O_3, no such information was available readily available to determine whether the cumulative lung function risk estimates were also heavily influenced by concentrations in the 25-55 ppb range. EPA (2014b) notes that the risk function is logistic and therefore provides greater weighting to the higher 8-hour concentrations in comparison to the lower values. The risk function shows little response when ambient concentrations are generally less than 20 ppb for the 10 percent FEV_1 decrement. As emissions are reduced to attain the proposed standard levels, the higher concentrations will shift downward, while the lower concentrations will shift upward. Both the high and the low concentrations will therefore shift toward the mid-range concentrations (i.e., 25-55 ppb), which are heavily influenced by background O_3. Therefore, it is important to assess the role that the mid-range concentrations play in the cumulative lung function risk estimates as emissions are reduced. Recognizing that cumulative mortality and morbidly epidemiological risk estimates were heavily influenced by background O_3 and we now explore the degree to which lung function risk estimates may be influenced by the mid-range concentrations.

Gradient, an environmental and risk sciences consulting firm located in Cambridge, MA, and A.S.L. & Associates worked together to explore to what degree the lung function risk estimates were heavily influenced by concentrations in the 25-55 ppb range. Gradient applied the Air Pollutants Exposure (APEX) model to estimate children's lung function decrements under various air quality scenarios using 2007 data for Los Angeles, Denver, Houston, Philadelphia, and Boston. For each of the 5 cities, five APEX scenarios (i.e., current, 75 ppb, 70 ppb, 65 ppb, and 60 ppb) were run. The simulations were based on the APEX modeling conducted by the EPA which is described in the HREA (EPA, 2014b), including the use of the threshold version of the McDonnell, Stewart, and Smith (MSS) model to estimate decrements in forced expiratory volume in 1 second (FEV_1). The EPA provided Gradient with the same input files and parameters as the APEX modeling conducted by the EPA for Gradient's model simulations.

In the HREA, EPA (2014b) modeled the lung function decrements for 200,000 individuals aged 5-95 years, and reported statistics for various subgroups (e.g., children aged 5-18). Detailed statistics on lung function decrements for these subgroups for each city, year, and air quality scenario were presented in Appendix 6B (EPA, 2014f). In the Gradient analyses, a group of 200,000 individuals aged 5-18 years was modeled. To further analyze the results, Gradient extracted detailed model results for a randomly selected group of 25,000 of the 200,000 simulated children. This was necessary because the APEX output files for the total number of simulated children were too large for Gradient to analyze. The output data included FEV_1 decrements over the period of the simulation, divided into 1-60 minute events. For each of the 25,000 children, Gradient identified the maximum FEV_1 decrement during the simulated time period with duration of 60 minutes. Then, for each simulated child whose maximum FEV_1 decrement was >10%, Gradient extracted the hourly ambient O_3 concentration during the 60-minute event. Finally, Gradient binned the results by the ambient O_3 concentrations (in 5 ppb increments). Figure C-2 illustrates the APEX modeling process that Gradient employed.

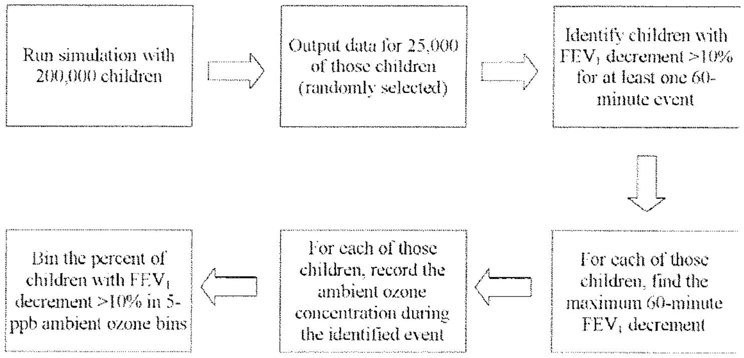

Run simulation with 200,000 children
Output data for 25,000 of those children (randomly selected)
Identify children with FEV₁ decrement >10% for at least one 60-minute event
For each of those children, find the maximum 60-minute FEV₁ decrement
For each of those children, record the ambient ozone concentration during the identified event
Bin the percent of children with FEV₁ decrement >10% in 5-ppb ambient ozone bins

Figure C-2. APEX modeling process used by Gradient for the 5 study cities.

The overall results for the Gradient APEX simulations of 200,000 children aged 5-18 were compared to EPA estimates to ensure that the modeling results were consistent with EPA's reported results. Specifically, Gradient's results were compared to the percent of children aged 5-18 years with FEV_1 decrements >10% that were presented in Appendix 6B (EPA, 2014f). Gradient's results for each simulated city and air quality scenario in 2007 were within 1% of EPA's. This indicated that Gradient's analysis was based on a set of individuals that was similar to the set modeled in the HREA (EPA, 2014b). Table C-1 summarizes the comparison between Gradient's and EPA's results.

A.S.L. & Associates utilized the Gradient results from the APEX model to develop figures that illustrate the percentage of the cumulative frequency of responses associated with the 25-55 ppb range for the Los Angeles, Denver, Houston, Philadelphia, and Boston urban study areas. The estimated risk, summarized in 5 ppb concentration increments (i.e., bins), was summed over the 25-55 ppb range and divided by the total accumulated estimated risk and then multiplied by 100. This calculation provided the determination of the percentage of the

Table C-1. Comparison of APEX model results with final HREA FEV_1 decrement results (Tables in Appendix 6B, EPA (2014f))

Study area	Year	Scenario	% of school age children with FEV_1 decrement >10% (EPA HREA)	% of school age children with FEV_1 decrement >10% (Gradient results)	Difference (Gradient minus HREA)
Los Angeles	2007	base case	25.15	25.23	0.08
		75 ppb	17.45	17.93	0.48
		70 ppb	15.08	15.65	0.57
		65 ppb	13.12	13.36	0.24
		60 ppb	10.92	10.95	0.03
Denver	2007	base case	21.33	21.53	0.20
		75 ppb	18.24	18.47	0.23
		70 ppb	16.12	16.36	0.24
		65 ppb	13.77	13.99	0.22
		60 ppb	11.14	11.59	0.45
Houston	2007	base case	19.86	19.91	0.05
		75 ppb	12.31	12.43	0.12
		70 ppb	10.74	10.90	0.16
		65 ppb	9.29	9.40	0.11
		60 ppb	7.40	7.45	0.05
Philadelphia	2007	base case	27.22	27.66	0.44
		75 ppb	18.41	18.55	0.14
		70 ppb	15.69	15.78	0.09
		65 ppb	12.82	12.89	0.07
		60 ppb	10.39	10.41	0.01
Boston	2007	base case	21.88	21.98	0.10
		75 ppb	17.75	17.85	0.10
		70 ppb	15.17	15.42	0.25
		65 ppb	11.57	11.76	0.19
		60 ppb	8.88	8.97	0.09

cumulative frequency of responses in the mid-range concentration of 25-55 ppb. For 3 (i.e., Los Angeles, Denver, and Houston) of the 5 cities, a large percentage of the cumulative frequency of responses was affected by background-influenced mid-range concentrations (Fig. C-3). Figure C-3 summarizes the effect of background O_3 on EPA's lung function risk assessments (FEV_1 decrements >10%). This figure focuses on mid-range concentrations for children aged 5-18 based on APEX model output for Los Angeles, Denver, Houston, Philadelphia, and Boston.

For Los Angeles, a large percentage of the cumulative frequency of responses is associated with the 25-55 ppb range for attainment of the 75, 70, 65 and 60 ppb levels (Fig. C-3). Background O_3 plays an important role in the cumulative risk. The cumulative frequency of responses for daily FEV_1 decrements >10% were 9% (current level), 52% (attaining the 75 ppb level), 65% (attaining the 70 ppb level), 77% (attaining the 65 ppb level), and 91% (attaining the 60 ppb).

For the Denver urban study area, a large percentage of the cumulative frequency of responses is also associated with the 25-60 ppb range for attainment of the 75, 70, 65 and 60 ppb levels (Fig. C-3). The accumulative range for Denver was expanded from the 25-55 ppb to 25-60 ppb because background O_3 at this high-elevation study area is greater than at low-elevation sites. Lefohn et al. (2014) notes that background O_3 contributes approximately 70% to the observed concentration in the 55-60 ppb range (see Fig. A-6). The cumulative frequency of responses in the Denver urban area for daily FEV_1 decrements >10% were 33% (current level), 56% (attaining the 75 ppb level), 72% (attaining the 70 ppb level), 87% (attaining the 65 ppb level), and 97% (attaining the 60 ppb).

For the Houston area, a large percentage of the cumulative frequency of responses is associated with the 25-55 ppb range for attainment of the 75, 70, 65 and 60 ppb levels (Fig. C-3).

The cumulative frequency of responses in the Houston urban area for daily FEV_1 decrements >10% were 12% (current level), 49% (attaining the 75 ppb level), 64% (attaining the 70 ppb level), 80% (attaining the 65 ppb level), and 95% (attaining the 60 ppb).

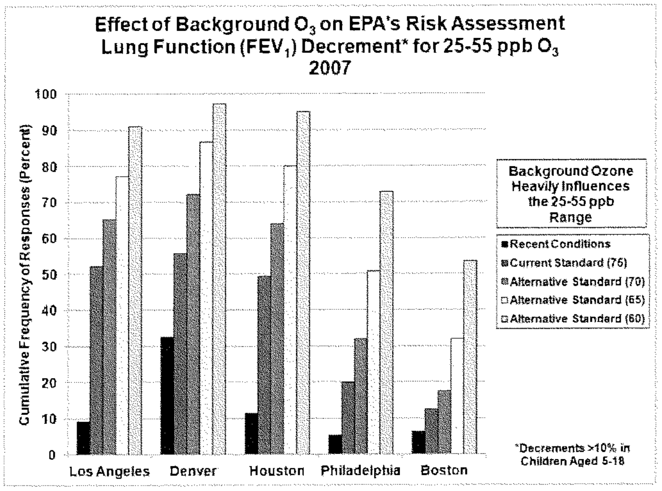


Fig. C-3. The percentage of the cumulative frequency of responses in children aged 5-18 associated with the 25-55 ppb range for the Los Angeles, Denver, Houston, Philadelphia, and Boston urban study areas using EPA's APEX model.

While the concentrations in the 25-55 ppb range played less of a role in the cumulative lung function risk analysis for Philadelphia and Boston than for the other 3 cities, a great deal of the accumulated risk was associated with the 25-65 ppb range, especially for the 65 ppb and 60 ppb scenarios (Fig. C-3). For Philadelphia, the cumulative frequency of responses for daily FEV_1 decrements >10% associated with the 25-55 ppb range were 5%, (current level), 20% (attaining the 75 ppb level), 32% (attaining the 70 ppb level), 51% (attaining the 65 ppb level), and 73% (attaining the 60 ppb). For Boston, the cumulative frequency of responses associated with the 25-

55 ppb range were 6% (current level), 13% (attaining the 75 ppb level), 18% (attaining the 70 ppb level), 32% (attaining the 65 ppb level), and 53% (attaining the 60 ppb).

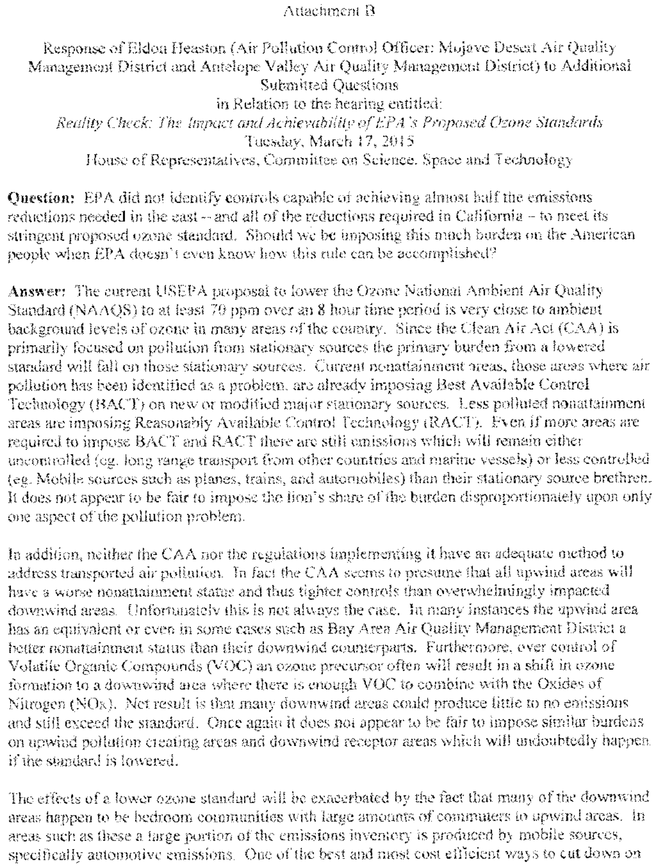
Similar to the morbidity and mortality health risk estimates that are heavily influenced by background O_3 in the 25-55 ppb range, the cumulative lung-function risk estimates for Los Angeles, Denver, and Houston also appear to be heavily influenced by background concentrations.

Biographic Sketches of the Authors

***Allen S. Lefohn** is President and Founder of A.S.L. & Associates in Helena, Montana, a firm he founded in 1981. He received his Bachelor's degree from UCLA in 1966 and a Ph.D. in physical chemistry from the University of California at Berkeley in 1969. Dr. Lefohn has published over 125 peer-reviewed publications, edited four books, presented oral papers, and participated in a number of panel presentations. During a career spanning almost 50 years, besides focusing his research on understanding the relative importance of background ozone, Dr. Lefohn's has developed exposure-response relationships and indices that describe the effects of ozone on vegetation and human health, as well as the analysis of air quality data in biologically relevant forms for effects assessment purposes. Dr. Lefohn was the lead consultant scientist for the EPA in authoring the air quality characterization chapter and the vegetation exposure-response section for the Ozone Criteria Document in 1996 and contributed to the Ozone Criteria Documents in 1985 and 2006. For the period 1989 – 1999, Dr. Lefohn served as an Executive Editor of the internationally recognized technical journal *Atmospheric Environment* and is an Emeritus Editor of the Journal. Dr. Lefohn is a co-guest editor with Dr. Owen Cooper of the NOAA Earth System Research Laboratory in Boulder, Colorado for the upcoming *Atmospheric Environment* special issue: Observations and source attribution of ozone in rural regions of the Western United States. In December 2014, Dr. Lefohn was invited to serve on the Steering Committee for the international research program, Tropospheric Ozone Assessment Report (TOAR): Global metrics for climate change, human health and crop/ecosystem research. The project will provide the research community with an up-to-date scientific assessment of tropospheric ozone's global distribution and trends from the surface to the tropopause. Besides focusing his professional time on scientific research, Dr. Lefohn is a professional photographer who captures the magical artistic moments associated with the performing arts (i.e., symphony and ballet). He is currently serving as the artistic photographer for the Helena Symphony. He has held the position since 2003. He is currently an Adjunct Professor of Environmental Engineering at Montana Tech in Butte, Montana.

†**Samuel J. Oltmans** is currently a Research Associate with the Cooperative Institute for Research in the Environmental Sciences (CIRES) at the University of Colorado at Boulder. Prior to his retirement in 2011, Mr. Oltmans conducted atmospheric and environmental research for NOAA/ESRL and its predecessors for nearly 40 years. Prior to joining NOAA Mr. Oltmans pursued graduate studies in Astro-Geophysics at the University of Colorado, where he worked with Prof. Julius London. After completing his graduate studies, Mr. Oltmans joined the newly formed Geophysical Monitoring for Climatic Change (GMCC) unit of the NOAA Air Resources Laboratory, where he had worked part time as graduate student. His initial research effort at GMCC was to establish a surface ozone monitoring program at several baseline observatories including Mauna Loa, Hawaii; Barrow, Alaska; South Pole, Antarctica; and American Samoa. These were among the first ozone observations in what is now termed the "background" atmosphere, remote from traditional locations that were nearly exclusively focused on polluted urban conditions. In addition to his work on tropospheric ozone, Mr. Oltmans has done extensive research on the stratospheric ozone layer. Mr. Oltmans has collaborated widely with fellow observationalists and modelers and has authored or co-authored over 240 peer-reviewed publications. Mr. Oltmans has received a Department of Commerce Silver Medal and Bronze Medals for his research contributions. He is a Fellow of the American Geophysical Union and a member of the American Meteorological Society. He recently received the American Geophysical Union Yorum J. Kaufman Unselfish Cooperation in Research Award given for broad influence in atmospheric science through exceptional creativity, inspiration of younger scientists, mentoring, international collaborations, and unselfish cooperation in research.

Responses by Mr. Eldon Heaston



Attachment B

Response of Eldon Heaston (Air Pollution Control Officer: Mojave Desert Air Quality
Management District and Antelope Valley Air Quality Management District) to Additional
Submitted Questions
in Relation to the hearing entitled:
Reality Check: The Impact and Achievability of EPA's Proposed Ozone Standards
Tuesday, March 17, 2015
House of Representatives, Committee on Science, Space and Technology

Question: EPA did not identify controls capable of achieving almost half the emissions reductions needed in the east -- and all of the reductions required in California – to meet its stringent proposed ozone standard. Should we be imposing this much burden on the American people when EPA doesn't even know how this rule can be accomplished?

Answer: The current USEPA proposal to lower the Ozone National Ambient Air Quality Standard (NAAQS) to at least 70 ppm over an 8 hour time period is very close to ambient background levels of ozone in many areas of the country. Since the Clean Air Act (CAA) is primarily focused on pollution from stationary sources the primary burden from a lowered standard will fall on those stationary sources. Current nonattainment areas, those areas where air pollution has been identified as a problem, are already imposing Best Available Control Technology (BACT) on new or modified major stationary sources. Less polluted nonattainment areas are imposing Reasonably Available Control Technology (RACT). Even if more areas are required to impose BACT and RACT there are still emissions which will remain either uncontrolled (eg. long range transport from other countries and marine vessels) or less controlled (eg. Mobile sources such as planes, trains, and automobiles) than their stationary source brethren. It does not appear to be fair to impose the lion's share of the burden disproportionately upon only one aspect of the pollution problem.

In addition, neither the CAA nor the regulations implementing it have an adequate method to address transported air pollution. In fact the CAA seems to presume that all upwind areas will have a worse nonattainment status and thus tighter controls than overwhelmingly impacted downwind areas. Unfortunately this is not always the case. In many instances the upwind area has an equivalent or even in some cases such as Bay Area Air Quality Management District a better nonattainment status than their downwind counterparts. Furthermore, ever control of Volatile Organic Compounds (VOC) an ozone precursor often will result in a shift in ozone formation to a downwind area where there is enough VOC to combine with the Oxides of Nitrogen (NOx). Net result is that many downwind areas could produce little to no emissions and still exceed the standard. Once again it does not appear to be fair to impose similar burdens on upwind pollution creating areas and downwind receptor areas which will undoubtedly happen if the standard is lowered.

The effects of a lower ozone standard will be exacerbated by the fact that many of the downwind areas happen to be bedroom communities with large amounts of commuters to upwind areas. In areas such as these a large portion of the emissions inventory is produced by mobile sources, specifically automotive emissions. One of the best and most cost efficient ways to cut down on emissions caused by commuters is to reduce the vehicles miles traveled (VMT). The simplest way to reduce VMT is to have the jobs closer to the people performing them. Unfortunately in the industrial sector a lower ozone standard will make it that much more difficult to move manufacturing and industrial operations as well as attract new job opportunities. Once again the proposed lower standard will be more difficult to attain and disproportionately place the burden on sources that are already highly regulated.

Finally, when analyzing the potential burden of the proposed lower ozone standard the effects of the previous 2008 change in the Ozone NAAQS have not really been considered. Due to our litigious society, especially in the environmental field, implementation of the current Ozone NAAQS is only recently becoming widespread. In the Mojave Desert and Antelope Valley Air Quality Management Districts (MDAQMD and AVAQMD respectively), for example, we are just now updating our rules and regulations to obtain reductions mandated under the current standard. This delay means that we are most likely not yet seeing the full extent of air quality improvements driven by the current standard. Likewise we are not yet seeing the full economic impact of the current standard on regulated industry. What we are seeing, however, is that due to the presumptions inherent in the CAA is the concentration of polluting activities in areas that are already carrying a heavy burden of air pollution. The requirement of offsetting emissions reductions means that the areas which have many sources of pollution are the only areas where offsets can be created and thus the only areas where new industrial activity may occur. Decentralizing pollution sources into areas with a better carrying capacity is highly difficult and in some case well-nigh impossible under the current CAA rubric.

In my opinion, from the vantage point of a primary regulator in direct contact with the regulated community and the general public, if the NAAQS are indeed lowered to the proposed standard the resultant burden will only be eased by an overhaul of the CAA.

Question: Your colleagues at the South Coast Air Quality Management District recently considered banning beach bonfires to meet air standards. Is this an example of the types of measures that EPA refers to as "unknown controls"?

Answer: As the Air Pollution Control Officer (APCO) of another air district in a completely different air basin I am most likely not the correct person to answer questions regarding the underlying justifications for the banning of beach fires within the South Coast Air Quality Management District (SCAQMD). It would be much more appropriate for the committee to request information from SCAQMD directly regarding how the proposed ban fits into the context of their overall air quality attainment planning efforts. As far as I am aware, SCAQMD was not planning to take credit for emissions reductions caused by the proposed ban to meet their air quality attainment goals.

As a person with expertise in air quality issues the SCAQMD's action seems to be primarily a response to a local nuisance issue. In Southern California beach fires are generally viewed as a ceremonial event and in some cases part of an unofficial rite of passage. Some beach communities welcome such events while others have issues with the practice. This varies widely based upon local land use, terrain features, prevailing wind direction as well as cultural factors.

Separately and together these factors can impact the burden placed upon local residents by such fires.

Burning of charcoal and clean wood primarily produces Particulate Matter (PM) emissions rather than ozone precursors. Problems tend to arise when other material is burned, either intentionally or inadvertently due to trash or other debris being left in a fire ring. Burning of such extraneous materials can create at best a nuisance and at worst a toxic air contaminant problem downwind. I believe that SCAQMD's ultimate solution regarding limiting the numbers of fire rings and assisting local communities with the location and spacing of such rings is a reasonable solution to what appears to be a local issue involving area residents feeling overwhelmingly impacted by out of area beach users.

Question: EPA's cost analysis claims that the costs of implementing its proposed ozone standard have gone down by $29 billion in the last four years. Is this consistent with your experience – has there been some sort of breakthrough in the last four years?

Answer: To my knowledge there has not been an overall breakthrough causing a massive reduction in the costs of control equipment during the last four years. As you are aware BACT and RACT are both industry specific and a moving target. Both BACT require that the technology be achieved in practice and both have some measure of cost analysis. Of course the more application and production of a particular technological control means that the cost will go down. Cost reductions of this type may not, in many cases, be significant due to the costs of the base materials to produce things such as specialized catalysts. In addition, many of these technologies are not fungible and must be specifically tailored to meet the requirements of a particular source's emissions. Thus, costs and labor used to design and install such technology will remain high.

Another factor to consider is that a lower ozone standard may force many areas to impose controls that are beyond BACT. In fact this is already happening in SCAQMD where BACT requirement are often times closer to a standard known as Lowest Achievable Emissions Rate (LAER). LAER has no cost consideration and thus is the most stringent, and most costly, control available. I fear that EPA's cost analysis had not factored in the potential for area to be required to impose LAER level controls in order to meet the proposed lower standard.

Question: EPA assumes a lot of so-called "unknown controls" to accomplish its stringent proposed ozone standard. Does the use of the words "unknown controls" give confidence that extent or cost of unpopular measures required to achieve the proposed standard is really understood?

Answer: In my experience "unknown controls" is a euphemism for "technology forcing" requirements and "LAER, LAER everywhere." Also in my experience, the interaction of LAER level controls and technology forcing measures can have serious unintended consequences. For example, an aerospace company in one of my districts installed a Regenerative Thermal Oxidizer (RTO) to burn off excess VOC from their assembly and painting processes. This action was taken in an attempt to meet BACT levels of emissions (which happened to be closer to LAER) at the time. In a parallel track a technology forcing rule resulted in reformulation of coatings to drastically lower the amount of VOC. VOC emissions were reduced to the point that the RTO cannot be operated without burning natural gas as a supplemental fuel but the VOC emissions are still too high to meet BACT levels. Net result is additional NOx from combustion coming out of the RTO. I have yet to see EPA adequately address such issues in any of their rule making activities.

Question: EPA assumes "unknown future technologies" will be developed to meet their stringent regulations. Is this a reasonable assumption? What are "unknown controls" in practice? Are they measures like shutting down power plants, less economic activity and mandatory electric cars?

Answer: The development of "unknown future technologies" is going to be highly variable and industrial source category specific. Some industrial operations will have potential for innovation while others do not. The problem with technology development is that you cannot legislate a breakthrough. You can encourage technology development if you are willing to commit substantial funding and intellectual resources to the effort. Even if you create the environmental control technology equivalent of the famed Manhattan Project there is no guarantee that any cost effective, usable control technology will be developed.

"Unknown controls" are just as variable and uncertain. They could be as easy as implementing vapor recovery systems on all gasoline dispensing stations nationwide or shifting all drycleaners to wet based cleaners. They could be as onerous as mandatory "no drive" days or combustion free, all-electric zones.

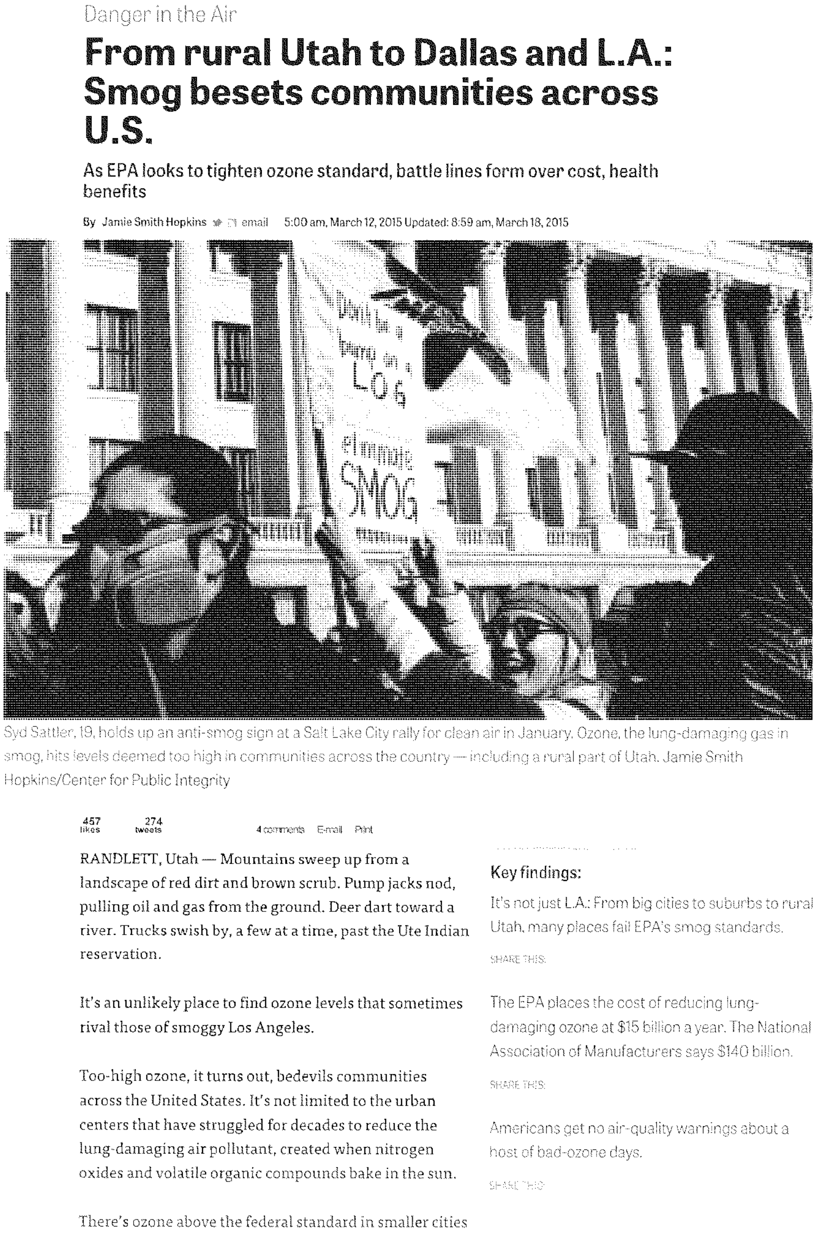
In my experience the more stringent the controls the greater the potential for creating additional problems. An all-electric zone in Southern California for example will require power to be generated somewhere. At least some of that power will need to be combustion generated as solar, wind and other renewables are variable sources which may not always be available when power is needed. Similarly, the construction and maintenance of certain control equipment can in and of itself cause emission of air contaminants as well as produce waste products which may be toxic or otherwise difficult to properly dispose of. Often a newly reformulated product such as paint will cause, due to its wear characteristics, a corresponding increase in application of the product resulting in little or no decrease in emissions over time. To make matters worse stringent controls often result in playing air quality "whack-a-mole" where the control for one pollutant creates an increase in another such as combustion for control of VOC often results in increases in NOx and Greenhouse gas emissions.

"Unknown controls" are just that, unknown. Without specifically identified technologies it is unclear whether there will be enough investment in new technologies to meet the proposed new ozone standard without draconian lifestyle restrictions being imposed.

Appendix II

ADDITIONAL MATERIAL FOR THE RECORD

SUBMITTED BY COMMITTEE RANKING MEMBER
EDDIE BERNICE JOHNSON



Danger in the Air

From rural Utah to Dallas and L.A.: Smog besets communities across U.S.

As EPA looks to tighten ozone standard, battle lines form over cost, health benefits

By Jamie Smith Hopkins email 5:00 am, March 12, 2015 Updated: 8:59 am, March 18, 2015

Syd Sattler, 19, holds up an anti-smog sign at a Salt Lake City rally for clean air in January. Ozone, the lung-damaging gas in smog, hits levels deemed too high in communities across the country — including a rural part of Utah. Jamie Smith Hopkins/Center for Public Integrity

RANDLETT, Utah — Mountains sweep up from a landscape of red dirt and brown scrub. Pump jacks nod, pulling oil and gas from the ground. Deer dart toward a river. Trucks swish by, a few at a time, past the Ute Indian reservation.

It's an unlikely place to find ozone levels that sometimes rival those of smoggy Los Angeles.

Too-high ozone, it turns out, bedevils communities across the United States. It's not limited to the urban centers that have struggled for decades to reduce the lung-damaging air pollutant, created when nitrogen oxides and volatile organic compounds bake in the sun.

There's ozone above the federal standard in smaller cities

Key findings:

It's not just L.A.: From big cities to suburbs to rural Utah, many places fail EPA's smog standards.

SHARE THIS:

The EPA places the cost of reducing lung-damaging ozone at $15 billion a year. The National Association of Manufacturers says $140 billion.

SHARE THIS:

Americans get no air-quality warnings about a host of bad-ozone days.

SHARE THIS:

such as Cincinnati, Ohio, and Middletown, Connecticut. Because the stuff doesn't stay put, it's often worse in suburbs than car-clogged downtowns. And it's over the threshold in parts of the Mountain West, exactly where you'd expect the air would be cleanest.

But even that fails to capture the full picture. For almost a decade, the U.S. Environmental Protection Agency's independent scientific advisory committee of researchers and doctors has said the nation's ozone standard is too lenient, a point of view backed by the American Academy of Pediatrics **and other health groups.**

EPA's science advisers have said since '06 that U.S. ozone standards don't protect health.

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Current U.S. smog standard, set in 2008, is the first one that's stricter than the original limit set in 1971.

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That means people in a wide swath of the country breathe air that doesn't violate any rules — and thus doesn't trigger any warnings — and yet, according to research, is unhealthy. That's particularly true for the young, the elderly, people with lung diseases and outdoor workers. As ozone rises, even to levels below the EPA's 75-parts-per-billion threshold, studies have found increased asthma attacks and respiratory-driven hospital visits. There's also growing evidence that ozone can affect the heart, increasing the risk of cardiac arrest.

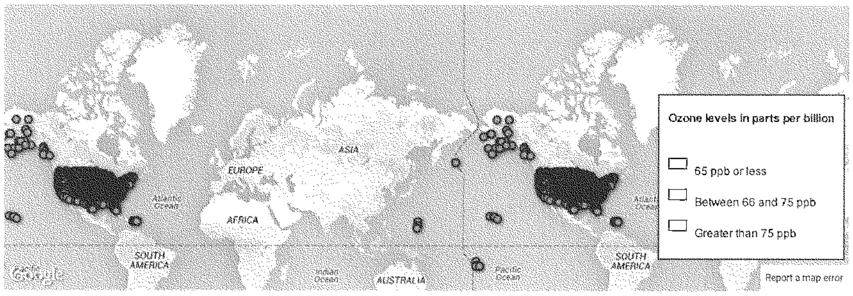
Winter Ozone in Utah's Uinta Basin

"The science is showing how much more harmful ozone is than we previously thought," said Janice Nolen, assistant vice president of national policy for the American Lung Association, which sued the EPA to press the agency to act.

The EPA's advisory committee has said since 2006 that the standard should be between 60 and 70 ppb. In November, the EPA proposed a range of 65 to 70 ppb, saying it would save both medical costs and lives.

The geography of smog

The U.S. Environmental Protection Agency wants to tighten its standard for ozone, the lung-damaging gas in smog. It's considering a range of 65 to 70 parts per billion, any part of which would put a significantly broader swath of the country out of compliance, requiring government agencies and industry in those places to step up pollution-control efforts. This map shows which counties measured ozone levels below and above the proposed limit, including which areas topped the current 75 ppb standard, during 2011-2013. Click on counties for more information.



Source: U.S. Environmental Protection Agency

"There are millions of Americans who suffer from asthma, or their kids do," Janet McCabe, acting assistant administrator for the EPA's Office of Air and Radiation, said in an interview. "The American people are entitled to know whether their health is at risk based on the amount of ozone in the air."

A final rule is due by October 1.

The EPA's proposal turned a years-long cold war into a hot one. Tightening the rule by just 5 ppb could cost certain industries billions of dollars a year to better rein in ozone-causing emissions.

Those pollutants come from a variety of activities that make modern society tick. Car tailpipes. Power plants. Factories. Refineries. Natural gas wells. Paints and other consumer products. Whenever the EPA proposes new ozone standards, the pushback is rapid.

The National Association of Manufacturers said the rule would be "the most expensive regulation ever imposed on the American public." A U.S. Chamber of Commerce official testified in January that the proposal could cause "potentially devastating economic and employment impacts." The American Petroleum Institute insisted that the current standards already protect public health.

Businesses haven't made the same arguments in Canada, which has a voluntary 63-ppb standard. Much of that country has reduced ozone levels below the range under consideration here. But the statements from American industry — especially predictions of economic devastation — echo every U.S. ozone battle for the past four decades.

Not every old argument has been resurrected. No one seems to be seriously suggesting this time, as the American Petroleum Institute did in the 1970s, that the major polluters are trees.

But now, with ozone well below where it was in those years, trade groups and some states say future reductions will be far more difficult.

"What we're bumping up to in the West especially is ... we get things in from California, we get a lot of tropospheric ozone coming in from Asia, and so if EPA puts that ozone level down towards 60 ppb, we could wipe out all human activity and we still would have pretty high ozone," said Kathleen Sgamma, vice president of government and public affairs with the Western Energy Alliance, an oil-and-gas industry group.

McCabe said the EPA doesn't ask high-ozone communities to stop growing and will work with areas that have unique challenges. The National Association of Clean Air Agencies, which represents the officials in 41 states and 116 localities who handle ozone efforts, endorsed a tighter standard this year.

But the last time the EPA considered taking this action, it was staved off by intense lobbying. There's plenty of that going around again.

Fourteen of the companies and groups that consistently lobbied Congress, the EPA or both on ozone in the past two years have publicly stated their positions on a tighter standard. Only two — the lung association and the League of Conservation Voters — are for it. The rest — business interests, largely trade groups representing manufacturers and energy firms — are against it, according to a Center for Public Integrity analysis of federal disclosure data.

"We absolutely at this point are urging the EPA and anybody else who will listen to us to keep the current standard," said Ross Eisenberg, vice president of energy and resources policy at the National Association of Manufacturers, which hears about regulatory delays and high expenses from members in ozone "nonattainment" areas. "At a time when ... we're having a manufacturing comeback largely because of energy, this just seems like the wrong way to go."

A stricter standard could affect almost every state. The EPA says 358 counties had ozone levels in recent years that would violate a 70-ppb rule, about two-thirds of which are out of attainment with the current standard. At 65 ppb, the number rises to 558 counties.

Under the Clean Air Act, the EPA can freeze federal highway funds and impose other sanctions on areas that exceed health standards. But regions need only to submit plans and take steps toward achieving goals. McCabe said she expects many communities will be able to push their ozone below the threshold just by reaping the benefits of already enacted federal rules. A major one is a 2017 change in fuel standards.

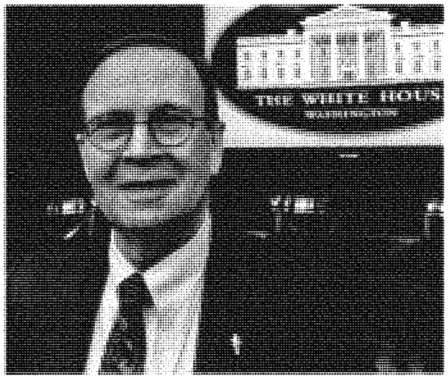
> *"As my lungs got worse, the high ozone would affect them more and more. It would be like going outside on a subzero day — my lungs would just freeze up."*
>
> - Daniel M. Dolan-Laughlin, a retired railroad executive

Ozone isn't something most people worry about. It's confusing, for one. Up in the stratosphere, ozone is good, creating a layer that protects against ultraviolet radiation. It's the stuff down at breathing level that's bad, irritating the lungs and — research suggests — inflaming the blood vessels.

On top of that, it's invisible. Only when it mixes with particle pollution does it pop into view as smog and offer a visual cue that something's wrong with the air.

But Daniel M. Dolan-Laughlin pays close attention to ozone levels near him. He's had to ever since chronic obstructive pulmonary disease began making everyday activities difficult in the 1990s.

"As my lungs got worse, the high ozone would affect them more and more," said Dolan-Laughlin, a retired railroad executive who lives in a suburb of Chicago.



Daniel M. Dolan-Laughlin, a Chicago-area resident who has testified in favor of clean-air regulations, said high ozone made it increasingly hard for him to breathe as his lung disease worsened. He received a double lung transplant in 2011. Even now, he wears a mask if he must go out when ozone levels climb. Courtesy of the American Lung Association

His disease made it increasingly hard to breathe, forcing him into early retirement in 1994 and later onto oxygen from a tank. Even with the oxygen, he couldn't go outside when ozone levels rose.

"It would be like going outside on a subzero day," he said. "My lungs would just freeze up."

Dolan-Laughlin received a life-saving double lung transplant in 2011. Now he can walk up stairs without pausing every few steps to gasp. He's climbed several mountains, in fact. But he won't go out on bad ozone days without a mask.

Dolan-Laughlin, who has testified at EPA hearings in favor of a variety of clean-air rules, hopes the agency will tighten its ozone standard.

"I'm a strident capitalist," he said, "but I'm also an environmentalist just out of common sense."

Dianne LaFaver, a teacher who lives in the Dallas-Fort Worth metroplex, an ozone-challenged region, also wants a tighter standard.

LaFaver's daughter, 22-year-old Laura Day, has asthma. Before Day left the area for college, her mother twice had to rush her to the emergency room on high-ozone days.

"She hadn't been exercising, which was the normal trigger," LaFaver said. "She hadn't been stressing herself. We were just in the car. ... At the emergency room, they were saying they were having lots of visits."

Dr. Alfred Munzer, a lung-disease specialist who retired last year from Washington Adventist Hospital in Takoma Park, Maryland, saw 40 years' worth of patients affected by ozone. There were the asthma attacks triggered by it — ozone causes spasms in the respiratory tract — and the infections that cropped up a day or two later because the pollutant interferes with the lungs' ability to cleanse themselves, he said.

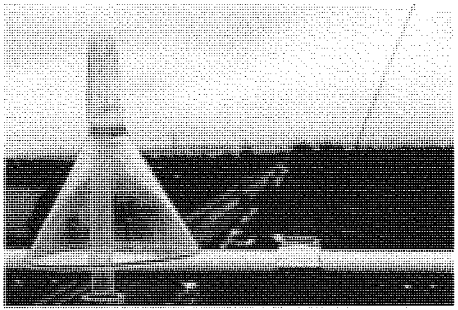
"There really is, as far as I know, no really safe level of ozone," said Munzer, a former president of the American Lung Association.

The American Academy of Pediatrics has warned that children are more susceptible to ozone's effects because their bodies are still developing. The EPA's proposal, the group said in November, is "long overdue."

The politics of ozone

That's also the message coming from the EPA's Clean Air Scientific Advisory Committee Ozone Review Panel, whose 20 scientists and doctors are largely drawn from universities.

Last year panel members unanimously recommended tightening the ozone standard. While they said a range of 60 to 70 ppb would be better than the current threshold, they warned that the upper end might not "protect public health with an adequate margin of safety."


Pumps suck in air through this funnel atop an air-monitoring station in Roosevelt, Utah, to test for ozone levels. Jamie Smith Hopkins/Center for Public Integrity

The panel unanimously recommended the same range in 2006, under President George W. Bush. And in 2008 and 2011, for good measure.

The panel considered the science. Out in the wider world, politics took over.

Though the EPA can consider only public health when it sets the standard, not factors such as cost, the agency disregarded its advisory committee's recommendation in 2008 and lowered the threshold from 80 ppb only down to 75. The EPA reconsidered the matter after Barack Obama was elected president. But following industry lobbying, he blocked the agency from setting a lower level in 2011.

Obama said he didn't support a change at that time, given that the standard was due for reconsideration in 2013. And he emphasized "the importance of reducing regulatory burdens and regulatory uncertainty, particularly as our economy continues to recover."

Then and now, business groups and key Republicans in Congress have contended that a lower standard would be too costly and difficult.

"EPA's proposal ... will lower our nation's economic competitiveness and stifle job creation for decades," U.S. Sen. James M. Inhofe said in a statement in November. Now chairman of the Senate Environment and Public Works Committee, he plans to hold hearings about the standard.

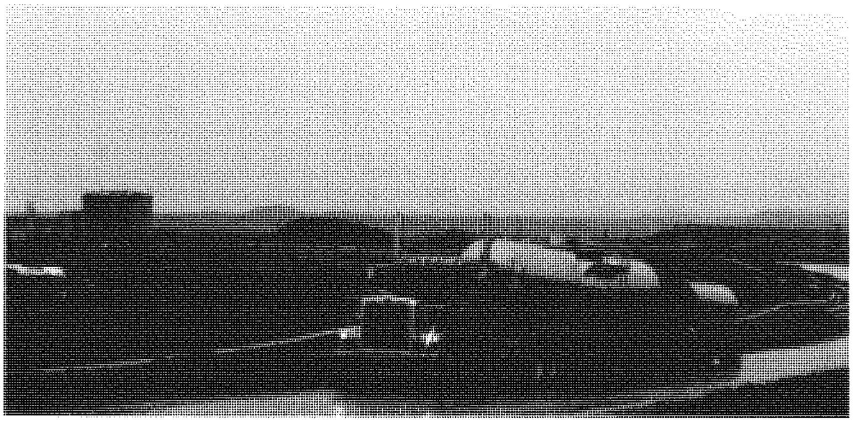
Air-quality officials in some states see a tighter standard differently — as a welcome relief.

Maryland is one example. Despite its ozone controls, the state had some of the highest concentrations in the East from 2011 to 2013, according to the most recent data from the EPA.

That's because on almost all bad ozone days, the air already violates current standards as it crosses into Maryland, said Tad Aburn, director of the state's Air and Radiation Management Administration. He wants to see upwind states reduce their smog, so he favors a stricter standard. "It's really a regional problem," he said.

An unexpected location

Air-quality field tech Mike Natchees traveled a wide-open stretch of road one drizzly January morning, past sagebrush, pump jacks and a gas flare burning like an oversized birthday candle. His goal: a shed-like structure atop an unpaved hill. Inside, devices measure how much ozone is in the air.



A tanker winds around a road on land overseen by the federal Bureau of Land Management. Oil and petroleum-waste trucks are a common sight in the Uinta Basin, but the agency says it's taking many steps to reduce traffic and other oil-related emissions. Jamie Smith Hopkins/Center for Public Integrity

That air is in Ouray, Utah, part of the Ute tribe's 4.5-million-acre reservation. Cattle and wild horses probably outnumber the cars going by.

"Occasionally we see antelope out here," said Preston McDonald, the tribe's head of air-quality data analysis.

The reservation, along with wide swaths of federal land and small towns, makes up the Uinta Basin in northeast Utah. The mountain-encircled region sits far from urban areas. Population in the largest city, Vernal, barely tops 10,000.

Yet the region has an ozone problem. Not in the summer, but in the dead of winter.

Ozone has to be cooked into life by sunlight, which is usually too weak in the winter to produce much photochemistry. But reflection off snow gives the basin's sunlight an extra kick. Snow cover also causes temperature inversions that keep polluted air from rising out of the basin.

In such conditions, volatile organic compounds from thousands of oil and gas sites across this region drive ozone way up. In 2013, an inversion-heavy year, the eight-hour average ozone level in Uintah County — spelled with an "h," unlike the basin — exceeded the standard on 54 days. Concentrations spiked as high as 142 ppb, according to EPA figures. That's "code purple," the worst category for air pollution warnings.

Los Angeles County in California, by contrast, had 59 days that exceeded the standard that year, none of which were code purple.

The problem came to light in 2009 after a settlement between the EPA and an energy company operating on Ute land brought air monitors to the area, including the one in Ouray. The state kicked in money to study the problem. So did the Western Energy Alliance, federal agencies and other groups.

The studies determined that the oil and gas industry's volatile organic compounds, or VOCs, are the big contributor. Annual emissions in the basin are on par with the VOCs spewed from 100 million vehicles driven thousands of miles each, according to a University of Colorado Boulder study.

"What might need to be done ... and whether it would put the stranglehold on our oil and gas industry and shut it down, or whether just a little bit can make a big difference, are questions that are open still," said Seth Lyman, a basin ozone researcher who heads Utah State University's Bingham Entrepreneurship and Energy Research Center.

The state of Utah requires stricter emission controls at new oil and gas sites than it did several years ago and passed regulations last fall to phase in retrofits of older, leaky equipment.

"VOC emissions should be reduced pretty dramatically ... as things tighten up," said Brock LeBaron, the state's deputy director of air quality.

Seth Lyman, executive director of Utah State University's Bingham Entrepreneurship and Energy Research Center, is a key ozone researcher in the Uinta Basin. He's based in Vernal. Jamie Smith Hopkins/ Center for Public Integrity

The environmental group WildEarth Guardians argues that those efforts aren't sufficient, given the problem's scale, and contends that all levels of government are falling down on the job in the basin. Many wells are on federal land.

The EPA has also declined to designate the area in violation of current ozone rules. (Its decision hinges on the fact that much of the past ozone data comes from monitors run by companies, not the government.) WildEarth Guardians sued over the matter in 2012 and awaits a ruling.

Several weeks ago, WildEarth's Jeremy Nichols drove from Vernal to a wildlife refuge in Randlett, pointing out pump jacks and the tanker trucks that continually travel to and from the basin.

"It's dangerous, the scale and pace of development," said Nichols, the group's climate and energy program director. "You're seeing that with the air-quality issues. I mean, *Vernal* has a big-city ozone problem?"

It's a place that in some ways looks as small-town as it is. A bubblegum-pink fiberglass brontosaurus grins at motorists above Vernal's welcome sign, one of many local nods to the fossil-studded Dinosaur National Monument nearby.

But it's also a town with 19 hotels and motels. Its glassy library and other high-end public buildings are different sorts of monuments than the pink dinosaur, ones that speak to years of oil-related taxes and royalties.

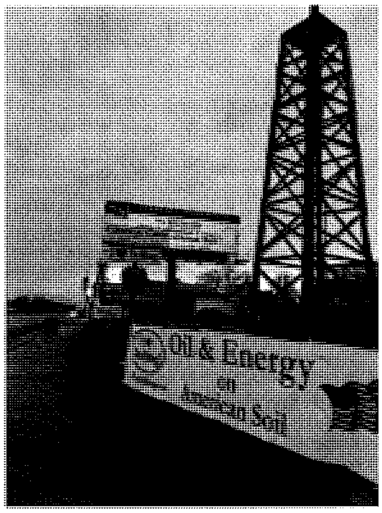
The owner of a juice and smoothie bar put up a miniature oil rig outside his business with a sign that seems to sum up the local sentiment: "I (heart) Drilling!"

Oil and gas is the biggest employer in this county, according to state data. The industry directly accounts for about a fifth of the jobs here, and Uintah County Commission Chairman Michael McKee says it rises to half if you add in the ripple effect.

"You take any community, state or region with those dynamics, it's important that we protect our jobs," he said. "It's also important that we have clean air and clean water and a good environment."

Still, McKee sees a tighter ozone standard from the perspective of a job threat, one that looms as the region heads into an oil bust. Plunging prices prompted layoffs here and the fear of more.

McKee said officials are working on the ozone problem, but he doesn't see how the basin could meet a tighter standard. While the area doesn't get inversions every winter — McKee described the air as often "pristine" — compliance is judged based on a three-year average of each year's fourth-highest daily reading. Inversion years go awfully high.



A miniature rig beside the main drag in Vernal, in Utah's Uinta Basin, stands as one business owner's thumbs-up to drilling. Jamie Smith Hopkins/Center for Public Integrity

Utah State University studied asthma-related hospital visits and didn't see an impact from the area's high-ozone days, McKee added.

Lyman, whose center wrote that study, is quick to insert a cautionary note: Unlike Atlanta, central New Jersey and other urban areas where studies have found links, the basin has a tiny population. That makes it difficult, if not impossible, to jump the bar of statistical significance.

"We think there certainly is an impact, but exactly how it compares to summertime urban ozone is probably never going to be found out because there's just not enough people here," Lyman said.

Ozone, at least, is quiescent this winter. Warm temperatures have kept snow from piling up, warding off an inversion.

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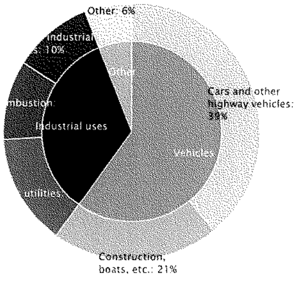
But the VOCs are still here, millions of cars' worth, ready to react when conditions are right. Stephanie Howard and Megan Crandall, both with the federal Bureau of Land Management in Utah, drove through the Pariette Wetlands area in the basin on a recent afternoon, explaining what the agency is doing to reduce emissions from ubiquitous oil and gas equipment. Steps include eliminating VOC-heavy evaporation ponds and pressing operators to replace leaky valves.

U.S. manmade nitrogen oxides emissions



Source: Center for Public Integrity analysis of U.S. Environmental Protection Agency estimates.

At the same time, the bureau is reviewing whether to allow more than 8,500 additional oil and gas wells in the region, double the number now under its jurisdiction. Leonard Herr, an air resources specialist for the Bureau of Land Management in Utah, knows that poses a tough question: Can total emissions be reined even as sources multiply?

He's optimistic about that. And he doesn't view a tighter ozone standard as a looming disaster for the basin.

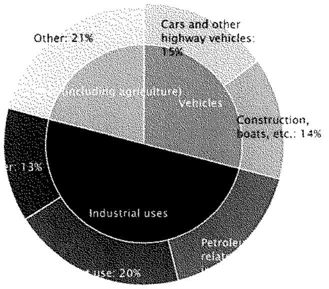
U.S. manmade volatile organic compound emissions

"Nonattainment and failure to meet the standards after that isn't the end of the world," he said. "Just look at L.A. It's been nonattainment almost my whole adult life, and it's not a barren wasteland of economic development."

The cost debate

When the EPA sets its ozone standard, the Supreme Court ruled in 2001, the Clean Air Act mandates that only one factor be weighed: what the best available science shows people can safely breathe.

Some members of Congress want to change that. Among the flurry of ozone bills submitted last year was the industry-supported "Clean Air, Strong Economies Act," which would have required the agency to consider cost. It also would have barred a new standard from taking effect until 85 percent of counties failing the old standard fixed their air.



Source: Center for Public Integrity analysis of U.S. Environmental Protection Agency estimates.

The companion bills, sponsored by U.S. Sen. John Thune, R-S.D., in the Senate and U.S. Rep. Pete Olson, R-Texas, in the House, didn't get put to a vote last year. The bills were referred to committees that are now both headed by Republicans opposed to tighter ozone standards, which could give the measures new life if reintroduced as planned this year.

The National Association of Manufacturers' Eisenberg characterized the effort as a way to give the EPA more flexibility, though he acknowledged that the group hasn't spent much time considering how that might affect public health.

"We're certainly hoping to have that discussion," he said.

What's more evident to manufacturers is the business impact when a community tips into ozone nonattainment. They must more than offset any pollution added if they want to expand or build something new, Eisenberg said. That could mean buying pricey credits on the emissions-offset market or shutting down another pollution source, he said, so more often manufacturers simply go elsewhere.

The EPA argues that the value of its proposal outweighs the expense because medical care and missed work days from ozone-triggered health problems add up fast. The agency estimated the benefit of a 65-ppb standard at $19 billion to $38 billion a year beginning in 2025, when it expects most of the country would meet that tighter threshold, compared with an estimated $15 billion in annual costs.

Trade groups say the negative impact would be far higher. A study for the National Association of Manufacturers suggests a 65-ppb standard would cost the U.S. economy $140 billion a year. The effects would include fewer jobs, higher electricity costs and restricted fossil-fuel production, the study says.

The Congressional Research Service weighed in last fall to declare the impact too far off to estimate. Ozone rules usually have deadlines that are years, even decades, into the future, and they often spur new, less expensive pollution technology.

"Aside from some statutorily mandated compliance measures, states — not EPA — decide what sources will be regulated and how stringent the controls will be," the nonpartisan think tank added in its issue brief. "Often, industry can choose how to comply."

Given that, the actual cost of past ozone reduction would be useful to know. But those numbers don't seem to exist, despite all the effort spent trying to estimate them in advance the past 40 years.

The EPA, working with economists, did put a price tag on the expense of reducing all the pollutants covered by the Clean Air Act. Their $22-billion-a-year tally for 1973 to 1990 was less than half the annual amount the American Petroleum Institute projected in 1979 for the cost of reducing ozone alone.

The ozone seesaw

In the history of environmental action, 1970 was a watershed year. President Richard Nixon created the EPA and — over the strenuous objections of automakers — signed the Clean Air Act into law.

"Through our years of past carelessness we incurred a debt to nature, and now that debt is being called," Nixon, a Republican, said in his 1970 State of the Union address.

The Clean Air Act prompted the first national ozone standard, set at 80 ppb the next year. Catalytic converters followed, eventually reducing vehicle pollution in a big way.

But amid the high oil prices and inflation of the later '70s, the Carter administration targeted regulations that advisors and industry argued were more cost than benefit. Carter's inflation-fighting economists questioned whether the ozone studies of the time, then less definitive, really demonstrated that the pollutant needed to be reduced as much as the standard suggested. Up it went in 1979, to 120 ppb.

Industry groups had called for the standard to be set at 160 ppb or higher. Even 120 ppb, the American Petroleum Institute argued, would prompt "extensive social and economic disruption," *The Washington Post* reported at the time.

The institute was then in the midst of an ozone lawsuit. The EPA, the trade group alleged, suppressed research showing the main source of smog was natural vegetation.

Patrick R. Zimmerman wrote those EPA-funded studies, and he says the agency did drag its feet in allowing him to publish his results. Later, he realized that officials were worried someone would

Ozone timeline

1971 **First ozone standard**

First ozone standard enacted in the U.
President Richard Nixon launches the

1975 **Auto makers take action**

Major auto manufacturers release car
substantially reduce pollution leading

1970s **New standards face pressure**

Pressure mounts on the EPA over its
Carter administration's inflation-fight

1979 **EPA yields, loosens standard**

The EPA raises its ozone threshold to

1997 **Back to 80 ppb**

The EPA tightens the ozone threshold
barbecues and lawnmowers could foll

2001 **Supreme Court steps in**

The U.S. Supreme Court rules that, co
consider only what is safe to breathe

purposely misinterpret his findings — which is what he says the institute did.

Trees and vegetation, Zimmerman found, emit certain VOCs at such high levels that they far out-produce man-made sources in forest-heavy regions. But that doesn't mean urban smog is a tree problem, Zimmerman said — it's not. (Rarely is ozone formed without an assist from man-made pollution, the EPA says.)

Zimmerman was appalled at what happened next.

"The American Petroleum Institute ... wrote articles that they planted in all kinds of magazines and newspapers," said Zimmerman, a scientist who now runs an environmental-technology firm in South Dakota. "It must have been 100 of them. Each article was pretty much the same, and it said something like, 'Trees emit so much pollution, we can't possibly control ozone, and the standards should be higher.' "

That apparently made an impression on Ronald Reagan. While running for president, he said trees and plants were bigger polluters than cars — his so-called "killer trees" moment.

The petroleum institute didn't respond to the Center's requests for comment.

Zimmerman couldn't believe how little the actual science seemed to matter. He was glad to get out of ozone research.

"I really underestimated the importance of politics," he said.

'Dirty secret'

Outside Utah's state Capitol building in January, several thousand people pressed together, some carrying signs, some wearing gas masks. They cheered speakers railing against air pollution. They clapped as a band turned the heavy-metal anthem "We're Not Gonna Take It" into "We're Not Gonna Breathe It."

"People have just had enough," said Daniel Roper, a Salt Lake City resident who attended the rally with his 21-month-old son. "It's Salt Lake City's dirty secret. We didn't know about it when we moved here."

Salt Lake City, like the Uinta Basin, is a region with air-quality challenges — ozone in the summer and harmful particulate matter in the winter. But unlike the Uinta, there's a large contingent of residents here who loudly press officials to do more about it.

Nearly nine in 10 Utah residents view air pollution as a "serious problem," driven by concerns in the Salt Lake area, according to a Colorado College poll released in February.

2006

EPA considers tougher standards

With research showing harms from lo
scientific advisory panel on ozone una
level between 60 and 70 ppb.

2008

New standard prompts criticism

EPA sets the ozone standard at 75 pp
level "fails to satisfy the explicit stipulat
margin of safety for all individuals."

2010

Obama's EPA

EPA, now under President Barack Oba

2011

Obama intervention

As the EPA prepares to set a tighter st
changed yet because it is due to be re

2013

Health groups sue EPA

With no ozone reconsideration under
sue the EPA.

2014

New standards by Oct. 2015

After a federal judge sets deadlines fo
October 2015.

Rally speakers, elected officials among them, urged Utah's legislature to accelerate efforts to clean the state's air and criticized businesses that put themselves on the other side of the debate.

"Without public health, there is no prosperity," said the Rev. David Nichols of Mount Tabor Lutheran Church in Salt Lake City, one of the speakers.

Cherise Udell, a rally organizer who founded the 3,000-member Utah Moms for Clean Air, hates the jobs-vs.-air argument with a passion. She has a different way of looking at clean-air standards: Who should pay for pollution?

Once, she says, everybody threw their waste into the streets. Then it became clear how unsanitary that was, and people had to shell out to get their trash hauled away.

She contends that some businesses are still dumping their garbage into the community by polluting the air — making other people pay for it in medical bills and worse health.

"That's completely and utterly unfair," Udell said. "If your neighbor was doing that, you'd be outraged."

Maryam Jameel and Alexander Cohen of the Center for Public Integrity contributed to this article. A version of this story also appeared on National Geographic's site.

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DANGER IN THE AIR

In Texas, Environmental Officials Align With Polluters

The state of Texas is as aggressive as industry in battling a new national health standard for smog.

By **Jamie Smith Hopkins**, Center for Public Integrity
PUBLISHED MARCH 17, 2015

Editor's Note: This is the second part of a two-part series produced in partnership with the Center for Public Integrity. Read part one here.

The testimony sounds the refrains of industry groups: Tightening the country's smog standard would be too costly, and it isn't necessary for public health.

But these comments weren't from industry. They were written by the chair of the Texas agency responsible for environmental protection.

The state of Texas is as aggressive as some industry associations in battling a proposed tightening of health standards for ozone, the main ingredient of smog. Officials there have spoken before Congress, hired a consultant firm to question the health benefits of a more stringent standard—the same firm hired by the American Petroleum Institute—and introduced bills to fundamentally change how ozone is regulated nationwide.

This is a long-standing strategy for Texas, where power plants, cement factories, refineries, and other facilities produce far more ozone-causing pollutants than those in any other state, according to a Center for Public Integrity analysis of U.S. Environmental Protection Agency data. Texas officials have butted heads with the EPA over ozone since the 1970s.

"They've been fairly consistently against clean-air protections," said Elena Craft, a senior health scientist at the Environmental Defense Fund.

Though ozone levels are markedly better now, compared with past decades, parts of Texas, particularly in the Dallas-Fort Worth and Houston areas, have some of the nation's highest readings.

The Texas Commission on Environmental Quality said in an emailed statement that it's trying to ensure that rules are necessary before they're imposed.

"TCEQ has concluded that there will be little to no public health benefit from lowering the current standard," the agency's chairman, Bryan Shaw, said in written testimony at a December Senate hearing.

More Industrial Emissions Than Any Other State

Nitrogen oxides (NOx) and volatile organic compounds (VOCs) form ozone at ground level as they cook in the sun.

Cars are a major source: Highway vehicles account for about 40 percent of NOx and 15 percent of VOCs in the United States, according to EPA figures. But power plants, factories, oil refineries, and other industrial facilities are big contributors too.

That's particularly true in Texas, according to 2011 EPA data, the most recent.

Texas's 340,000 tons of NOx emissions from facilities' stacks and vents topped the emissions in number two Pennsylvania, home of big coal-fired power plants, by more than 60 percent. At 105,000 tons, VOC emissions from facilities in Texas were 44 percent higher than those in number two Colorado, even though Colorado—another oil and gas hub—had far more sources producing those pollutants.

California has a greater number of facilities emitting NOx than any other state—more than twice the number Texas has, according to the EPA data. And yet California's collectively spew a quarter of the NOx emitted by Texas facilities. It's a similar story with VOCs.

"Because we have had such a bad air-quality problem for many years, there's been a lot of strict controls that have been put into place," said Sylvia Vanderspek, chief of the air-quality planning branch at California's Air Resources Board. "So our stationary sources are very well controlled."

In Texas, the commission points to the state's success in reducing emissions. Annual NOx from facilities totaled 900,000 tons as recently as 1998, but they've dropped since the EPA's tally and are now below 300,000 tons, according to the state's data.

Ozone levels have dropped as a result, improving 24 percent between 2000 and 2013, according to the TCEQ. That improvement came as the state added more than 5.5 million people and their ozone-contributing vehicles.

Still, California cut ozone levels faster.

The Los Angeles region has the nation's worst ozone levels. But the rest of California had less smog than Texas's Brazoria County, near Houston, and the Dallas-Fort Worth suburb of Denton County in 2011-13.

Tom "Smitty" Smith, the Texas office director for the consumer advocacy group Public Citizen, credited Texas with doing "some very aggressive things" to attack smog. But "overall," he said, "the state has failed to live up to its obligations to protect its citizens from poor air quality."

The Ozone Fight

In 2013, the TCEQ gave a consulting firm, Gradient, a two-year contract worth up to $1.65 million to "critically review" the science behind the EPA's ozone and other air-pollution standards. The EPA has proposed to tighten the ozone standard from 75 parts per billion to between 65 and 70 ppb.

Gradient wrote reports for the American Petroleum Institute, the Utility Air Regulatory Group, and other industry associations in the past several years, arguing that the EPA overstated ozone risks by relying on studies with limitations.

Gradient principal Julie E. Goodman, a toxicologist, co-wrote a *Wall Street Journal* opinion piece last year saying the "overwhelming body of scientific evidence" suggests the current standard is sufficient. A PowerPoint presentation she made to the TCEQ last fall pointed to the studies' limitations and "inconsistent" results.

Ozone researchers, however, disagree. The evidence of health risks above 60 ppb "is clear," said Mary B. Rice, a pulmonary critical care physician at the Harvard-affiliated Beth Israel Deaconess Medical Center, in Boston.

Texas doctors have become increasingly vocal about the issue. This year the Dallas County Medical Society called on the EPA to tighten the standard and urged the state to take more aggressive actions to battle smog, rather than smog rules.

"Everyone's aware of the really serious health effects in this area," said Robert W. Haley, chief of epidemiology at the University of Texas Southwestern Medical Center in Dallas.

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NATIONAL GEOGRAPHIC

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Reforestation as a novel abatement and compliance measure for ground-level ozone

Timm Kroeger[a,1], Francisco J. Escobedo[b], José L. Hernandez[c,2], Sebastián Varela[b,3], Sonia Delphin[b], Jonathan R. B. Fisher[a], and Janice Waldron[d]

[a]Central Science Department, Nature Conservancy, Arlington, VA 22203; [b]School of Forest Resources and Conservation, University of Florida, Gainesville, FL 32611; [c]ENVDAT Consulting, Knoxville, TN 37923; and [d]Texas Operations, Dow Chemical Company, Freeport, TX 77541

Edited* by Peter M. Kareiva, Nature Conservancy, Seattle, WA, and approved August 14, 2014 (received for review May 27, 2014)

High ambient ozone (O_3) concentrations are a widespread and persistent problem globally. Although studies have documented the role of forests in removing O_3 and one of its precursors, nitrogen dioxide (NO_2), the cost effectiveness of using peri-urban reforestation for O_3 abatement purposes has not been examined. We develop a methodology that uses available air quality and meteorological data and simplified forest structure growth-mortality and dry deposition models to assess the performance of reforestation for O_3 precursor abatement. We apply this methodology to identify the cost-effective design for a hypothetical 405-ha, peri-urban reforestation project in the Houston–Galveston–Brazoria O_3 nonattainment area in Texas. The project would remove an estimated 310 tons of (t) O_3 and 58 t NO_2 total over 30 y. Given its location in a nitrogen oxide (NO_x)-limited area, and using the range of Houston area O_3 production efficiencies to convert forest O_3 removal to its NO_x equivalent, this is equivalent to 127–209 t of the regulated NO_x. The cost of reforestation per ton of NO_x abated compares favorably to that of additional conventional controls if no land costs are incurred, especially if carbon offsets are generated. Purchasing agricultural lands for reforestation removes this cost advantage, but this problem could be overcome through cost-share opportunities that exist due to the public and conservation benefits of reforestation. Our findings suggest that peri-urban reforestation should be considered in O_3 control efforts in Houston, other US nonattainment areas, and areas with O_3 pollution problems in other countries, wherever O_3 formation is predominantly NO_x limited.

air pollution | ecosystem services | natural infrastructure |
state implementation plan

Ground-level (tropospheric) ozone (O_3) is a secondary air pollutant formed through the chemical interaction of nitrogen oxides (collectively referred to as NO_x and comprising NO and NO_2) and volatile organic compounds (VOC) in the presence of conducive solar radiation and temperature conditions (1). Ground-level O_3 is considered one of the most pervasive and damaging air pollutants globally, with background concentrations that have more than doubled in the northern hemisphere since the late nineteenth century (2). Despite widespread and often decadeslong control efforts, ambient O_3 concentrations in urban areas in many parts of the world regularly exceed the World Health Organization guideline value of 50 parts per billion (ppb; daily 8-h average concentration) (3).

Despite the highly complex nature of estimating O_3 health effects (4), O_3 has been linked to increased mortality in humans (4–7), with an estimated annual death toll of 28,000 in Europe (8) and 152,000 [95% confidence interval (CI): 52,000–276,000] globally (9), and to reduced worker productivity (10) and increased respiratory and cardiovascular disease (7, 9). In Europe, an estimated 39,000 respiratory hospital admissions per year are attributed to O_3 concentrations above 35 ppb (8). In the United States, an estimated 10.7 (90% CI: 5.5–15.8) million acute respiratory symptoms; 5,300 (90% CI: 0–11,900) respiratory emergency room visits; 4,100 (90% CI: 1,100–7,900) respiratory hospital admissions; and 3.7 (90% CI: 1.6–5.9) million school loss days could have been avoided per year on average during 2005–2007 if O_3 concentrations in those years had been reduced such that their 8-h averages would not have exceeded 60 ppb anywhere (11). Ozone also has been shown to reduce food crop and forest productivity (12, 13) and is an important greenhouse gas (2).

Efforts to reduce ambient concentrations of O_3 and other pollutants have relied predominantly on engineering-based approaches to reduce emissions from fossil fuel combustion processes, implemented via command-and-control or market-based mechanisms (14).These have included physical dilution of emissions via tall stacks (15); intermittent or permanent, partial, or complete plant shutdowns (16); conversion to lower-emitting combustion processes and fuels (17); and end-of-pipe controls (18).

Despite these control efforts, high ambient O_3 concentrations remain a widespread problem in many areas of the world. In the United States, O_3 is regulated by the Environmental Protection Agency (EPA) as a hazardous air pollutant. In 2013, there were 46 areas with a total population of 123 million that were designated as O_3 nonattainment areas because at least one monitor exceeded the 75 ppb (daily 8-h average) 2008 National Ambient Air Quality Standard (NAAQS) for O_3 3 times a year (19). States

Significance

Despite often decadeslong control efforts, in many regions of the world ambient concentrations of ground-level ozone threaten human and ecosystem health. Furthermore, in many places the effects of continuing land use and climate change are expected to counteract ongoing efforts to reduce ozone concentrations. Combined with the rising cost of more stringent conventional technological ozone controls, this creates a need to explore novel approaches to reducing tropospheric ozone pollution. Reforestation of peri-urban areas, which removes ozone and one of its precursors, may be a cost-effective approach to ozone control and can produce important ancillary benefits. We identify key criteria for maximizing the ozone abatement and cost effectiveness of such reforestation and the substantial potential for its application in the United States.

Author contributions: T.K., F.J.E., J.R.B.F., and J.W. designed research; T.K., F.J.E., J.L.H., S.V., S.D., and J.R.B.F. performed research; T.K., F.J.E., J.L.H., and J.R.B.F. analyzed data; J.W. contributed data; and T.K. and F.J.E. wrote the paper.

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[1] To whom correspondence should be addressed. Email: tkroeger@tnc.org.

[2] Present address: US Department of the Interior, Bureau of Ocean Energy Management – Gulf of Mexico Region, New Orleans, LA 70123.

[3] Present address: Centro de Transporte Sustentable de México-EMBARQ-WRI, México, D.F. C.P. 04000.

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are required to develop and implement EPA-approved State Implementation Plans (SIP) for each nonattainment area that outline measures deployed to achieve attainment. Because EPA has jurisdiction over mobile sources, states pursue attainment principally by imposing emission limits on large industrial processes and utilities (point sources) and smaller stationary processes (area sources). Due to the often dominant (>50%; NO_x) or large (25–50%; VOC) contribution of point sources to total stationary O_3 precursor emissions, the imposition of limits on permitted point source precursor emissions is a key SIP component in these nonattainment areas. Point sources comply with their NO_x emission limits by installing combustion controls (fuel switching, low-NO_x burners, fuel reburning, flue gas recirculation), end-of-pipe controls (selective catalytic or noncatalytic reduction), or by purchasing emission credits on the precursor-specific cap-and-trade markets established for many nonattainment areas. The 1990 Clean Air Act Amendments (20) create a further incentive for attaining NAAQS by imposing fines for VOC and NO_x emissions from major sources in areas that fail to meet attainment deadlines.

In the United States, the O_3 problem may worsen due to continuing land use and climate change, especially rising temperatures (21–24). A possible tightening of the O_3 NAAQS due to health concerns (25) may cause further reductions in precursor emission limits in many areas. The picture is similar in many other regions of the world (2). Because marginal control costs are increasing (26), achieving additional abatement will become increasingly costly. Thus, there is a pressing need to find new, cost-effective approaches to addressing the O_3 problem.

One as yet largely unexplored possibility for O_3 abatement is reforestation. Forests have been shown to reduce ambient concentrations of many anthropogenic air pollutants, in both urban and immediately adjacent peri-urban areas located between rural areas and the outer boundary of urban settlements (27–30). Trees absorb and diffuse ambient NO_2 and O_3 via dry deposition and foliar gas exchange, lowering the concentrations of these gases in the air mass moving through the forest canopy (27). Trees also release VOCs in response to many biophysical factors, increasing ambient VOC concentrations (28). The net effect of a reforestation project on O_3 concentrations depends on the magnitude of these two processes and on whether the project is located in an area where O_3 formation is limited by available NO_x or VOC, respectively. Using atmospheric chemistry and transport and meteorological models, Alonso et al. (31) found that peri-urban forests near Madrid, Spain, were O_3 sinks. Using forest structure data and a coupled dry deposition and mesoscale weather prediction model, Baumgardner et al. (32) found that a peri-urban forest near Mexico City improved regional air quality by removing O_3 and respirable particulate matter.

These studies raise the question of whether reforestation–and forest management and conservation more broadly–might constitute a novel and cost-effective approach to O_3 abatement by removing its precursor gases from the atmosphere at lower cost per unit precursor removed than engineering alternatives. If so, regulated emitters with a portfolio of abatement choices—such as many point sources, which currently can choose to achieve compliance with their emission limits via installation of various control technologies, purchase of precursor emission credits on nonattainment-area–specific cap-and-trade markets, or both—in principle might deploy reforestation projects to generate part of the required precursor abatement. Previous analyses have found that urban trees can be a cost-effective public strategy for improving air quality (33, 34). However, the private cost effectiveness and financial feasibility for regulated point sources of using peri-urban reforestation projects for O_3 precursor control remains unexamined.

We develop an integrated methodology that provides guidance for evaluating the long-term performance of reforestation in peri-urban areas for O_3 control and analyzing its cost-effectiveness as a compliance approach. We select the Houston–Galveston–Brazoria (HGB) O_3 nonattainment area in Texas as a case study because it exceeds O_3 standards and exhibits large-scale reforestation potential.

We first identify key siting and design parameters that affect the cost of reforestation projects per ton (t) of O_3 precursors removed. Second, we develop a simplified tree growth-mortality model that predicts key forest canopy parameters that affect air pollutant removal. We use these canopy parameters along with meteorological and ambient pollutant concentration data and the Urban Forest Effects (UFORE) dry-deposition air-pollutant removal and biogenic emissions model (30) to generate estimates of pollutant deposition and biogenic VOC emissions for a hypothetical 405 hectare (ha) reforestation project in the HGB area. Next, we combine removal estimates and reforestation and land costs to estimate the cost of the project per ton of O_3 precursor abated, with and without the carbon (C) credits such a project could generate under the California Air Resources Board (CARB; ref. 35) forest project offset protocol, the highest-price carbon market US reforestation projects can currently access. We compare these costs with those of conventional point-source NO_x controls in the HGB area. We also quantify the social economic value of the C sequestered by the project. Finally, we identify where guidance is needed from regulatory authorities in the selection of key estimation parameters to reduce uncertainties and narrow ranges in pollutant removal and cost-effectiveness estimates.

It is important to note that peri-urban and urban forests provide a wide range of ecosystem services in addition to air-quality improvement (36, 37). Reforestation thus may yield a series of cobenefits not provided by conventional engineering-based controls.

Results and Discussion

Forests remove both O_3 and NO_2. However, because O_3 is not emitted directly, a SIP regulates point-source emissions not of O_3 but of its precursors, NO_x and VOC. Thus, the objective of an O_3 SIP reforestation project is the abatement of O_3 precursor equivalents. In the case of NO_x, these equivalents (NO_xe; *Case Study and Methods*) are the sum of the NO_2 directly removed by the forest, and the NO_x indirectly removed in the form of O_3 formed from NO_x and VOC. Because trees do not remove, but rather emit, VOCs (28), a reforestation project can only achieve removal of VOC equivalents (VOCe) if it removes more O_3 than forms from its VOC emissions. Whether the O_3 removed by the forest is equivalent to NO_x or VOC abatement depends on whether O_3 formation in the area is predominantly NO_x or VOC limited, respectively. Thus, depending on its location, a reforestation project may generate either only NO_xe or both NO_xe and VOCe abatement.

Model scenarios with different planting densities and stock sizes (*SI Appendix*, Table S1) identified seedlings planted at 1,500/ha as the planting design with the lowest cost per ton of NO_xe removed. Unless indicated otherwise, all results presented below refer to this design, which achieves maximum forest crown area in year 23 after planting (*SI Appendix*, Fig. S2).

Precursor and Ozone Removal, Carbon Storage, and VOC Emissions.

Based on our modeled forest structure and UFORE-estimated specific pollutant removal rates (Table 1), the reforestation project is estimated to remove a total of 309.7 t O_3 and 58.1 t NO_2 over our 30-y analysis period and store 24,574 t aboveground C at year 30. Annual air pollution removal was greatest in year 23 of the project at maximum canopy cover (O_3: 14,156 kg; NO_2: 2,659 kg), and C sequestration was highest in year 16 (1,153 t). For O_3 and NO_2, the predicted decline in annual removal rates

Table 1. Modeled forest structure parameters and specific pollutant removal for the 405-ha reforestation project

	Phase 1 (DBH < 12.7 cm)	Phase 2 (DBH ≥ 12.8 cm)
Forest structure parameter		
Number of trees	502,698	94,440
Average DBH (cm)	7.6	25.4
Average tree height (m)	7.8	15.9
Average crown height (m)	3.1	6.4
Average crown width (m)	3.0	7.1
UFORE modeled forest structure		
Average LAI	3.17	3.42
Total leaf area (m^2)	1,861,620	2,298,500
UFORE modeled air quality effects—Pollution removal		
NO_2 (g/m^2 crown area/y)	0.579	0.600
O_3 (g/m^2 crown area/y)	3.116	3.194

Modeling phases: 1—tree establishment (years 1–10) and 2—maturity (years 11–30).

after year 23 is due to the omission of natural forest regeneration from our model, making our removal estimates conservative.

At our estimated removal rates per hectare, reforesting half or all of the estimated potentially reforestable 189,400 ha of bottomland habitat in the HGB area (*SI Appendix*, Fig. S3) would abate an estimated average 2,426–4,852 t O_3 and 455–911 t NO_2 per year over 30 y. Using the reported HGB area, O_3 production efficiency envelope of NO_x of 3–8 (38, 39), this results in an estimated 995–1,641 to 1,990–3,282 t NO_xe removal per year, or ~1.7–5.5% of the average of the estimated 2006 and 2018 annual HGB-area NO_x point-source emissions of 59,700 t (40). While these abatement levels by themselves likely would not be sufficient to achieve attainment, they do amount to several percent of the additional abatement that may be needed (*SI Appendix*, section S3).

Estimated 30-y total VOC emissions of the cost-effective (1,500 seedlings/ha) planting scenario are 115 t of isoprene, 41 t of monoterpenes, and 197 t of other VOC.

Cost Effectiveness of Reforestation for Ozone Precursor Abatement. We compared reforestation and conventional controls in terms of 30-y present value (PV) cost per ton NO_xe removed. All cost-effectiveness estimates assume full provisional up-front credit of pollutant removal as per EPA guidance (41) and that our projections represent actual forest growth during the 30-y analysis period.

NO_x—land cost scenario 1: No land costs. The reforestation project would remove an estimated total of 209 or 127 t NO_xe over the 30-y analysis period in the "high" and "low" removal scenarios, respectively (incremental O_3 production efficiencies of $NO_x = 3$ and 8, respectively). On lands where reforestation does not incur land costs (*Private Land Opportunity Costs*), this translates into approximately \$1,680–\$3,210/t NO_xe (high removal) and \$2,770–\$5,300/t NO_xe (low removal), with the low and high values in each range resulting from low and high planting cost estimates, respectively (*SI Appendix*, Table S4). If CARB carbon offset revenues are included at \$12.25/t carbon dioxide equivalent (CO_2e), the cost-effectiveness of NO_xe removal improves substantially, to \$300–\$1,840 and \$500–\$3,030/t in the high and low removal scenarios, respectively. These latter ranges reflect expected revenue (\$372,400) and transaction costs (\$103,400) of carbon offsets (both PV at 7% discount rate) over the 30-y time horizon. Ozone accounts for 39% and 63% of the total removed NO_xe in the low and high removal scenarios, respectively.

In all but the low removal scenario–where a project receives less NO_x credit for the O_3 removed due to high O_3 production efficiency of NO_x–reforestation in the HGB area has a lower mean cost per ton of NO_xe removed than conventional NO_x controls (\$2,500–\$5,000/t) and NO_x allowances (\$3,300/t; *SI Appendix*, section S5); that is, permits granting a perpetual right to emit 1 t NO_x per year (Fig. 1). Because reforestation projects would be expected to be sited in areas where they generate the most precursor abatement per dollar, we expect our high-removal scenario estimates–\$1,680–\$3,210/t without, \$300–\$1,840/t with C offsets–to be more representative of actual projects. Importantly, contract bids would provide ex ante certainty for actual projects about planting, and thus project cost and cost per ton of NO_x removed.

NO_x—land cost scenario 2: \$4,940/ha. At a representative price of suitable lands in the study area of \$4,940/ha (*Case Study and Methods*), total planting-related project cost is more than 5 times the average cost (\$493,000; range \$333,000–\$654,000) in land cost scenario 1. As a result, reforestation is no longer cost competitive with engineering-based precursor abatement, even with C offsets (*SI Appendix*, Fig. S4).

VOC. A reforestation project could achieve net VOCe removal if it removed more O_3 than is formed from its VOC emissions. Because our case study project is not located in an area where O_3 formation is VOC limited, its O_3 removal is equivalent to abatement of NO_xe, not VOCe. Nevertheless, to assess whether the project might abate VOCe if it were located in VOC-limited portions of the Houston area (Galveston Bay or southern Harris County; ref. 42) we estimate its net O_3 balance in a VOC-limited area.

Using the maximum incremental reactivity (MIR; ref. 43) scales (gram O_3/gram VOC) to estimate the quantity of O_3 formed by its VOC emissions, the project would produce an estimated 1,650 t O_3 over the 30-y analysis period, or over 5 times the estimated 310 t O_3 removed via dry deposition (*SI Appendix*, sections S6 and S7). The MIR scale represents relatively high NO_x conditions (areas with high NO_x:VOC ratios like Galveston Bay or southern Harris County in the HGB area; ref. 42), where O_3 is most sensitive to changes in VOC emissions, and is most often used or proposed for use in regulatory applications (43). Other reactivity scales (43) yield lower O_3 production estimates that however still exceed estimated removal via dry deposition. Although these findings are based on simplified models and assumptions and should be considered preliminary given the complex nature of O_3 formation (44), they suggest that reforestation projects may not yield net VOC abatement.

Private and Social Value of Carbon Sequestration. The project generates C offsets with an expected net PV of \$269,000 and avoids social costs of carbon (SCC)—the sum of future damages from increased atmospheric CO_2 concentrations—with an estimated PV of \$1.96 million (3% pure rate of time preference [PRTP]) to \$3.25 million (2.5% PRTP). On public or private lands with a qualifying conservation easement, lower mandatory contributions to the CARB forest offset project buffer account (12% of calculated sequestration vs. 19% in our estimates) would increase net present offset value by 12%. We consider both private and social C value estimates conservative because of the exclusion of natural regeneration in our forest model, which reduces estimated C sequestration after year 20.

Sensitivity Analysis. Engineering-based NO_x control options have an average economic lifetime of only 20 y (45). Full replacement of NO_x control equipment in year 21, for example, would increase the abatement cost per ton of engineering-based controls by 18% (assuming annual maintenance and repair costs for chemical processes of 3% [ref. 46] of initial capital cost and a 7% discount rate; *Case Study and Methods*). Extending the time

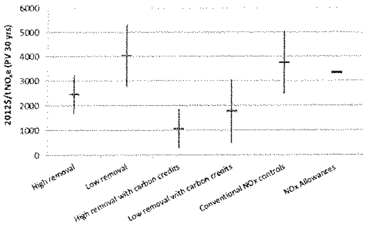

Fig. 1. Average cost per ton of NO_x control through reforestation at zero land cost, for high and low removal scenarios, and cost of standard point source controls and NO_x stream allowances in the HGB area. Vertical lines indicate ranges caused by different cost assumptions. Costs expressed as PV over 30-y period. NO_xe—NO_x equivalent.

horizon of the analysis also would increase the competitiveness of reforestation with conventional controls, as the established forest stand will keep removing O_3 and NO_2 at no additional cost beyond year 30. Thus, reforestation may be even more competitive with conventional NO_x controls than our analysis suggests.

Our finding that purchasing bottomland hardwood forest habitat for reforestation would not generate cost-competitive NO_x abatement is based on the assumption that emitters would fully absorb these costs. That may not necessarily be the case. Reforestation of former bottomland hardwoods can generate cobenefits, making cost-share arrangements likely for reforestation projects on some lands. Local and national stakeholders, such as the US Fish and Wildlife Service, the Texas chapter of the Nature Conservancy, and other conservation organizations in our study area have expressed strong interest in such cost-share arrangements for reforestation of ecologically valuable bottomlands. Whether cost sharing for purchased lands yields cost-competitive NO_x removal through reforestation of pasture lands depends on the cost shares. For example, at $4,940/ha land cost, cost sharing at 3:1 (project partner:point source) would achieve $2,690/t NO_xe in the best case (high removal, low planting cost plus C offsets) scenario, which would be competitive.

The competitiveness of reforestation projects may also be enhanced by interplanting of fast-growing species such as *Populus deltoides* in our study area to support a one-time selective timber harvest (47). The impact of such harvests on the cost per ton of NO_xe reduced depends on timber prices, volume harvested, accessibility, distance to the nearest mill, and requirements of the relevant C offset protocols.

The approach we present simplifies several complex biophysical processes. First, we were unable to find growth-mortality rates and allometric equations for seedlings and saplings of our bottomland hardwood species. Therefore, we assumed that our rates and equations can be applied to trees with a diameter at breast height (DBH) < 7.6 cm. Second, by not accounting for natural regeneration (47, 48) we underestimate total leaf area and air pollution removal during the later years of our analysis period. Likewise, our assumption that 2009 pollutant levels will remain constant may bias our estimates downward (*SI Appendix*, section S7). Third, we do not model effects of stochastic disturbance events like drought, wildfire, pests and diseases, or hurricanes in our analysis. However, our mortality rates are from a Houston study (49) covering an 8-y period that included a hurricane landfall (Hurricane Ike). Thus, they reflect recent historic pest and disease induced mortality, and implicitly assume an annual hurricane landfall probability of 1/8, although historic probability for our site (Brazoria and Fort Bend Counties) is <1/25 (50). Moreover, bottomland hardwoods are less prone to hurricane damage than mature, pine-dominated forest stands with large open-grown trees (49, 51). Southern bottomland forests also are less susceptible to drought than upland forests and have a low fire frequency (52), with fire risk for bottomland hardwoods in our area classified as very low (53). Overall, aggregate tree mortality risk from all pests and diseases in 2013–2027 is an estimated 1–5% at our study site and 1–15% for other bottomland forests in the area (54). The assumed 5.1–12% annual mortality rates for our project (*SI Appendix*, Table S2.5) thus exceed the combined risk from all these stochastic disturbance events. If disturbance risks were unknown or an additional margin of safety sought, a SIP could specify that a portion of estimated pollutant removal be deposited in a programwide risk buffer account, as is done in forest C offset protocols (35).

Another limitation is the use of pollution and weather data from fixed stations not located on our project site. Other studies on the effects of peri-urban forests on O_3 have used regional weather and chemistry models [e.g., Weather Research and Forecasting (WRF)-Chem; ref. 32]. The high sensitivity of the O_3 concentrations predicted by WRF-Chem and other advanced air quality models to meteorological conditions and the difficulty of accurately specifying those conditions for complex coastal zones make application of those models in the HGB area challenging (22, 55, 56).

Finally, the treatment of any net VOC emissions from a reforestation project will affect the overall cost effectiveness of such projects for O_3 precursor control, and hence their implementation. To promote reforestation for O_3 abatement without sacrificing air quality goals, it would seem appropriate to not debit a project with its VOC emissions as long as those emissions are unlikely to lead to O_3 formation. Such a treatment would be justified on the basis that it does not conflict with the defined policy (SIP) goal of reducing O_3 concentrations, but rather promotes adoption of novel O_3 control measures that would achieve additional O_3 abatement beyond that achieved by legally mandated control technologies. Application of such a differentiated treatment of VOC emissions and accurate conversion of the O_3 removed by a reforestation project to NO_xe both require reasonably reliable spatial information on the type (NO_x, VOC) and degree (i.e., production efficiency) of sensitivity of O_3 formation to ambient precursor concentrations, and can significantly affect the siting of reforestation projects and their cost per ton of precursor removal (*SI Appendix*, section S8).

Conclusion

Our analysis indicates that reforestation could be a viable, novel approach for abating ground-level O_3 pollution that complements conventional technology-based controls. Including reforestation in a comprehensive control strategy is desirable for regulators because it furthers attainment beyond what is achievable with current approaches considered technically or economically feasible. It is also desirable for regulated emitters because it may lower their compliance costs, in part due to the uniquely scalable nature of reforestation that contrasts with the lumpy costs and abatement provided by technological controls. We expect that reforestation in the Houston O_3 nonattainment area would be cost competitive with additional conventional point source NO_x controls on lands where it has negative or negligible opportunity cost for landowners and thus does not incur land costs. It may even be cost competitive on many additional lands where it does incur opportunity costs. These lands may need to be purchased, but acquisition costs may be defrayed through suitable timber harvests, or private or public cost-share agreements motivated by not only the high conservation value of those lands (57), but additional water quality (58), and recreation and scenic benefits restored forests may provide once established and mature (59, 60).

Our findings have implications for other areas with O_3 pollution problems in the United States and elsewhere. Given the large extent of suitable bottomland reforestation areas—historic bottomland forest currently in shrubland, grassland, or agriculture located in NO_x-limited portions of US O_3 nonattainment areas (Fig. 2) with similar O_3 and NO_2 concentrations (*SI Appendix*, section S7) and conventional NO_x control costs (*SI Appendix*, section S5)—we expect reforestation of peri-urban lands could be a cost-competitive NO_x control approach in many other existing US O_3 nonattainment areas. With high pollutant removal rates reported for peri-urban forests in high-O_3, NO_x-limited (61, 62) cities with deforested and degraded peri-urban areas in need of restoration such as Shanghai, China (63), and Mexico City, Mexico (32), reforestation may assist in O_3 control also in other countries.

Nevertheless, total pollutant removal by forests is space constrained: our study forest removes ~0.5 t NO_2 and 2.6 t O_3 km^{-2} y^{-1} and those in Shanghai and Mexico City remove around 2.1 t NO_2 km^{-2} y^{-1} (no O_3 removal estimate due to lack of ambient concentration data; ref. 61) and 0.04 t NO_2 and 1.7 t O_3 km^{-2} y^{-1} (32), respectively. Thus, reforestation clearly could not replace all additional, let alone existing, conventional controls.

In the United States, opportunities already exist to integrate reforestation into regulatory O_3 abatement efforts. Specifically, EPA's (41) policy "Incorporating Emerging and Voluntary Measures in a State Implementation Plan" encourages states to explore novel approaches to achieve NAAQS compliance. The policy defines as "emerging" a measure that does not have the same high level of certainty for quantification purposes as traditional measures but still fulfills the usual SIP requirements of being surplus, enforceable, quantifiable, permanent, and antibacksliding. It explicitly mentions tree planting as an example of an ambient concentration-reducing measure that could be used for purposes of SIP attainment, reasonable further progress, rate of progress, or maintenance requirements. Under this policy, being an emerging SIP measure, reforestation could not replace emission controls already mandated in a SIP (antibacksliding). Rather, it would form part of a suite of additional policies, incentives, and controls implemented for attainment or maintenance purposes.

Importantly, forests may lower ambient O_3 levels in NO_x-limited areas by more than a conventional control device with the same total annual amount of NO_xc abatement. This is due to the fact that photosynthetic activity and thus O_3 and NO_2 removal by trees are clustered around the O_3 season (May–September), and abatement by conventional controls is distributed more or less evenly throughout the year. Whether or not higher O_3 reductions would result in additional health benefits depends on differences in the spatial patterns of O_3 reductions produced by the two control options and resulting differences in total human exposure.

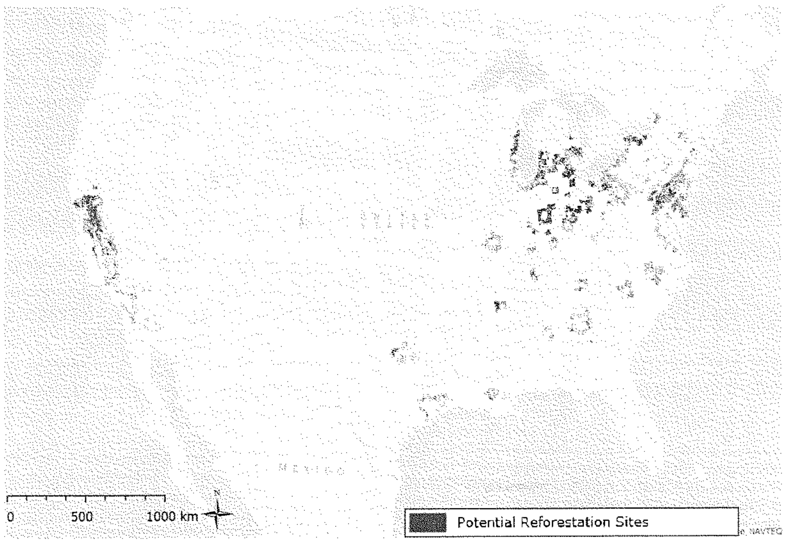

Fig. 2. Potential sites in the conterminous United States where reforestation could abate ozone. Sites were identified by intersecting O_3 nonattainment and maintenance areas (80 ppb 1997 8-h standard; ref. 19), NO_x-limited areas (formaldehyde/NO_2 ratio ≥1, from figure 6 in ref. 66), pre-European settlement forested areas [LANDFIRE Biophysical Settings Layer Refresh 2008 (lf_1.1.0), US Department of the Interior, Geological Survey, www.landfire.gov/vegetation.php] and lands presently under grass, shrub or agricultural cover (NLCD2006 Landcover, US Department of the Interior, Geological Survey, www.mrlc.gov/nlcd06_data.php).

In this paper we present, to our knowledge, a first attempt at constructing a methodology for integrating reforestation into O_3 control efforts. Making such integration a reality requires additional work, above all of the development of specific regulatory guidance that addresses several of the uncertainties outlined in our analysis, in particular the ozone production efficiency of NO_x; NO_x vs. VOC limitation of ozone production; and the portion of NO_xe abatement to be deposited in a SIP "buffer" account to hedge against catastrophic disturbance events, if any. In some cases, removing or reducing these uncertainties may require additional research.

Large-scale reforestation for O_3 abatement generally should be limited to NO_x-sensitive environments, as additional forest cover may increase O_3 levels in situations where O_3 formation is VOC limited (30, 44, 64, 65). It is important to note that with the exception of the urban cores of large metropolitan areas, many portions of O_3 nonattainment and maintenance areas in the United States (19, 66) and elsewhere (61, 62) are characterized as NO_x sensitive. Use of reforestation for O_3 abatement therefore may have widespread applicability. Our findings suggest that reforestation for air pollution abatement constitutes a potentially globally applicable example of "natural infrastructure" solutions to environmental challenges (e.g., 67, 68).

Case Study and Methods

Case Study Site. The eight-county HGB area has an average annual temperature between 15 and 20 °C (60 and 70 °F) and annual precipitation averages 1,020–1,530 mm (40–60'') (69). It lies primarily in the Gulf Coast prairies and marshes ecoregion, and partially in the upper west gulf coastal plain ecoregion (70), and contains the eastern two-thirds of the 515,000-ha Columbia Bottomlands Conservation area extending from the Gulf Coast inland along the Brazos, Colorado, and St. Bernard Rivers (57). Out of a total of ~189,400 ha potentially available for reforestation to bottomland hardwoods (*SI Appendix*, Fig. S3), we selected a 404.69-ha reforestation site located just north of Brazos Bend State Park (29°24'54''N, 95°33'51''W) expected to achieve high O_3 and NO_2 removal (*SI Appendix*, section S7). Historically forested, the site is now primarily grassland with sparse tree and shrub cover. Fig. 3 shows the HGB area, the study site, and the Texas Commission on Environmental Quality (TCEQ) monitoring stations from which pollution and meteorological data were obtained.

Forests in the HGB area have been declining primarily due to anthropogenic disturbances including timber harvest, agriculture, and urbanization (49, 51, 71). Bottomland forests in the region have experienced particularly high losses (72). Although this trend is predicted to continue in a business-as-usual scenario, improved forest protection could reduce future net forest loss (73), and coupled with large-scale reforestation might even reverse the long-term trend of declining forest cover. Bottomland forests in the HGB area have a high potential for restoration (57), are less susceptible to drought and wildfire than upland forests (49, 51, 52), and have high biodiversity and recreation value (57, 72). Thus, we chose a bottomland site for our analysis.

Selection of Suitable Reforestation Sites and Silvicultural Criteria. Planting site selection for O_3 and precursor control purposes should maximize pollutant removal per unit cost. Analysis of emissions, ambient concentrations, and wind data suggests that reforestation would remove the most O_3 in southern and southwestern Harris and in Brazoria County, and NO_2 removal would be highest in, and downwind of, the downtown Houston area and northwest of major NO_x point sources along the Gulf Coast (*SI Appendix*, section S7). Siting depends on whether NO_x or VOC abatement is prioritized (*SI Appendix*, section S8). We maximize NO_x abatement by locating the study site south of Houston in an area already high in biogenic VOC emissions (74) where O_3 formation is expected to be mostly NO_x limited--as it is in most of the HGB area (figure 2b in ref. 42) especially during late morning to late afternoon (42, 62) when biogenic VOC emissions are highest. Thus, VOC emissions from the additional forest are unlikely to lead to additional O_3 formation that would reduce the O_3 net balance of the project. Our case study site is located in Brazoria County (Fig. 3), just downwind of major industrial NO_x sources along the Gulf Coast and in the path of high NO_x concentrations and O_3 plumes drifting southwest over the Houston metro area (*SI Appendix*, section S7).

Our hypothetical project is a contiguous forest in a peri-urban area characterized by suitable soil and site properties. Such a design is expected to require less maintenance, be self-regenerating, and achieve lower mortality, allowing planting of smaller trees that in urban areas would be more prone to accidental or vandalism-related damage. This minimizes costs and emissions from maintenance, replacement, and monitoring activities (75, 76). We minimize VOC emissions by avoiding the planting of high-VOC-emitting species (*SI Appendix*, section S6).

Maximizing Precursor Abatement: NO_xe vs. VOCe. Ozone and NO_2 removal rates by trees generally increase with pollutant concentrations (29). Although very high pollutant concentrations can reduce photosynthetic rates

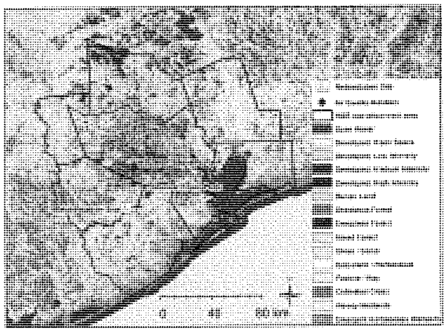

Fig. 3. Map showing the HGB nonattainment area, the reforestation site, Texas Commission on Environmental Quality air quality monitoring stations from which data were obtained, and land cover.

or makes trees more susceptible to other stressors such as insect or pathogen attack (77, 78), exposure levels to O_3 in the HGB area are not within the range that is expected to result in injury to shrubs and trees (79). We therefore assume that reforestation will achieve the highest O_3 and NO_2 removal rates in areas with the highest O_3 and NO_2 concentrations, respectively.

Nitrogen dioxide removal by forests–appropriately adjusted for uncertainties–can be translated directly into NO_x removal a reforestation project could claim. The calculation of the precursor removal a project could claim for the O_3 it removes is less straightforward. Ozone removal by forests is equivalent to avoiding emission of the precursor quantities used up in the formation of the removed quantity of O_3. Converting O_3 removed into its equivalent quantities of avoided precursors requires information on the O_3 production efficiency in the area, that is, the number of O_3 molecules formed from a precursor molecule (80).

Results from simulations (38) and measurement flights (39) indicate an O_3 production efficiency envelope of 3–8 in the HGB area for NO_x; that is, 3–8 O_3 molecules are formed per NO_x molecule oxidized during midday hours, making removal of an O_3 molecule equivalent to removal of 1/3–1/8 of a NO_x molecule under NO_x-limited conditions. We use this 3–8 range to develop high and low removal cases, respectively, for our reforestation project.

With O_3 formation in our study and much of the HGB area characterized as NO_x limited, we convert O_3 removed by the project to NO_2 equivalents (NO_2e) using the molecular weights of the two compounds and the 3–8 range of O_3 production efficiencies of NO_x (i.e., $1\ O_3 = 0.32–0.12\ NO_2$). Because point sources are regulated on emissions of NO_x (most of which are immediately converted to NO_2 in the atmosphere) and not NO_2, we follow existing policy guidance and convert NO_2e to NO_xe using the national NO_2:NO_x default ratio of 0.75 (81), which closely matches observed ratios of 0.73–0.74 in the HGB area (82).

Time Horizon of Analysis and Discount Rates. Both time horizon and discount rate affect cost-effectiveness estimates. We use a 30-y time horizon that somewhat exceeds the average 20-y lifetime of conventional NO_x control equipment (45) and the 25-y crediting period used for CARB forest carbon offset projects (35). Although the planted forest is expected to survive past 30 y and its cost-effectiveness increases with the time horizon, uncertainty as to future O_3 levels (and thus biogenic removal rates) and changes in the regulatory framework argue against much longer timeframes.

We use a 7% discount rate to calculate the PV of future project costs (SIP and C offset reporting and monitoring) and of C offset revenues, which "approximates the marginal pretax rate of return on an average investment in the private sector" (ref. 83, p. 9; *SI Appendix*, Table S9). We discount future SCC estimates using 2.5% and 3% discount rates, respectively (*Avoided Social Cost of Carbon*).

Reforestation and Silvicultural Characteristics. Rosen et al. (72) report that eight native tree species (*Carya aquatica, Celtis laevigata, Fraxinus pennsylvanica, Quercus nigra, Q. texana, Q. virginiana, Ulmus americana, U. crassifolia*) accounted for 87% of overstory basal area in a mature, protected bottomland hardwood forest in southwestern Brazoria County (*SI Appendix*, Table S2.1). Online reviews and phone inquiries with regional tree nurseries showed that six of these species (all but C. *laevigata* and C. *aquatica*) were commercially available in a variety of planting stocks and sizes. We selected these six species for planting and assume a constant forest composition (*SI Appendix*, Table S2.2) during our analysis period and no natural regeneration or introduction of any additional species.

We assessed possible climate change effects on our selected species using the *Climate Change Atlas for 134 Forest Tree Species* that predicts tree distribution ranges based on the random forests model (84, 85). Specific climate, topographic, soil, and land use parameters used in the random forest model and modeling methods are detailed in ref. 84. Our analysis suggests that habitat suitability in the bottomland forest areas in the HGB area will remain generally unchanged for the planted species during our time horizon (*SI Appendix*, Table S2.3).

Initial tree planting density and size affect overall pollutant removal and project costs and thus are key project design and modeling parameters. Recommended initial planting density for bottomland hardwood forests ranges from 400 to 3,000 plants per hectare (*SI Appendix*, Table S2.4). For this study we used 730 seedlings per hectare as a base case (47), based on recommendations for ecological restoration of bottomland hardwood forests in this region (86).

The size of tree planting stock, in terms of DBH or caliper (diameter at 61 cm above ground), is the dominant driver of reforestation costs. High-quality planting stock, and in general larger planting material, have overall higher survival rates (75) and thus will achieve a given age-specific target density with a lower initial planting density. Tree size also is positively related to crown area (87)–a key air pollution removal variable–and thus pollutant removal per tree is greater for larger trees in any given year. However, tree stock and planting costs also increase with tree size. The most cost-effective size at planting depends on all of these factors. Much of the scientific literature examining bottomland reforestation focuses on seedlings (*SI Appendix*, Table S2.4), which may be the most cost-effective size for adding trees in open, unpopulated areas (75). We modeled different tree size classes and planting densities to identify the cost-effective planting design for O_3 and precursor abatement.

Project Costs. Our SIP reforestation project costs comprise of (*i*) planting-related costs for project design, planting stock, site preparation and maintenance; (*ii*) land opportunity costs from forgone value of displaced land uses; and (*iii*) transaction costs for legal or coordination activities with regulatory bodies or third parties for initial project approval and for monitoring and reporting for SIP and carbon offset compliance (verification and registration) purposes, if any.

Planting-Related Costs. We obtained cost estimates for planting stock, site preparation, and labor (*SI Appendix*, Table S1) from the literature and regional providers (75, 88). Recommended site preparation techniques for hand and machine planting styles comprise reduction or elimination of weeds through prescribed fire, mowing, or double disking (89). Given expected constraints on the use of prescribed fire in our study area due to potential effects of smoke on air quality, we assumed site preparation by mowing and double disking.

For tree seedlings and planting costs, our low estimate combines a stock cost estimate of \$0.24 per seedling and Texas Forest Service per-acre cost estimates for hand planting (\$75) and mowing (\$33) as recommended for this planting option (89). Our high estimate uses Texas Forest Service estimates for hardwood seedling costs (\$0.60 each) and per-acre costs for planting by wildland machine (\$85) and double disking (\$115) as recommended for this planting option (89). We assume hand and machine planting costs per acre are for commonly used planting densities like those reported in Stanturf et al. (47, 86), and scale these costs proportionally for higher planting density scenarios.

Private Land Opportunity Costs. Land opportunity costs are highly dependent on the value of displaced, incompatible uses by owners. Not all uses are incompatible with reforestation–including timber production (48, 86), recreation opportunities or visual amenities for people living in the viewshed of reforested lands (59, 60), although the latter two are generally lower for peri-urban reforestation sites due to their initially dense, low-height structure and their location away from populated areas. Reforestation opportunities exist on public, deforested bottomlands currently under shrub or grass cover, and on large tracts of converted former bottomland hardwoods owned by companies with several large point sources in the area on which reforestation would not displace current or anticipated future high-value uses, thus incurring negligible land opportunity costs. Private third-party land owners might also be willing to have their bottomlands reforested for free or for a charge. With most converted former bottomlands currently in agriculture, we bracket potential opportunity costs by using two estimates: (*i*) zero cost; and (*ii*) \$4,940/ha–the approximate average fee-simple cost for nonwaterfront agricultural land in bottomland habitat in the area (*SI Appendix*, section S1).

Third-Party Land Opportunity Costs. Reforestation may impose costs on third parties by restricting the supply of developable land. Because of its small size and location away from urban expansion, this is not a concern for our case study project. It also generally is less of a concern for peri-urban reforestation. Furthermore, any development-related opportunity costs would be at least partially offset by property value premiums and nonmarket benefits owners of properties near reforested lands would receive (59, 60).

Transaction Costs. To satisfy SIP-related monitoring requirements (41), we assume that a site analysis (\$2,000 each) will be carried out every 3 y to assess whether tree survival and growth (key drivers of pollutant removal) match model predictions. We also assume an initial site inventory (\$10,000). If the project registers for CARB C offsets (35), the more demanding CARB inventory would be substituted for the SIP inventory. In the case of C offset generation, we assume an initial complete forest inventory (\$20,000) followed by full verifications (\$20,000 each) in years 14, 20, and 26, and annual interim verification and data reports (35) (\$5,000 each). All offset cost estimates are based on The Nature Conservancy data for California Climate Action Reserve integrated forest management offset projects.

Forest Canopy Modeling. We modeled tree canopy cover at annual time steps during the analysis period based on a simplified growth-survivability model and a tree stem-crown area allometric equation (49, 87, 90). We determined the cost-effective planting density and tree size by modeling O_3 and NO_2 removal and project costs for planting densities between 730 and 1,500 stems per hectare, for seedling and larger planting stock. We estimated the number of surviving trees (ST) during the 30-y analysis period from initial tree populations and DBH size-class-based growth and mortality rates (*SI Appendix*, Table S2.5) for Gulf Coast peri-urban forests (49, 90). These rates account for hurricane-related mortality. The annual tree crown width (CW) increments were then estimated using the following DBH-based allometric equation for Alabama *Quercus spp* (87):

$$CW = -0.8941 + 0.515\ DBH + 0.0059(DBH)^2. \quad [1]$$

Crown area (CA) for each year was calculated as CA = π x $(CW/2)^2$ for each individual tree and summed over ST. Natural regeneration or stand clearing disturbance events were not separately accounted for in our 30-y analysis period.

Air Pollution Removal, VOC Emission, and Carbon Sequestration Modeling. We used the UFORE model (UFORE-ACE version 6.5 with U4D020701.SAS and U4B020700 modules; ref. 76) and hourly pollution concentration and meteorological data from January 1 to December 31, 2009 (*SI Appendix*, Table S7.1) to estimate the annual removal of NO_2 and O_3 and VOC emissions per unit area of surviving tree cover using UFORE-estimated forest structure parameters (Table 1). Hourly pollutant concentrations and solar radiation data are from TCEQ's Manvel Croix Park C84 (29°31′–41′N, 95°23′–29′W) and Bayland Park (29°41′45″N, 95°29′57″W) monitors, respectively, and meteorological data (wind direction and speed, temperature, dew point, atmospheric pressure, precipitation, and sky cover) from the National Oceanic and Atmospheric Administration National Climatic Data Centers' Pearland station (29°31′1″N, 95°15′0″W). We assume that 2009 O_3 concentrations and meteorological parameters will remain constant over the 30-y analysis period (*SI Appendix*, section S7). Also, rather than model required UFORE structural parameters and annual air pollution removal and VOC emissions for every year in our 30-y analysis period, we use a simplified approach and model two representative urban forest structural phases (Table 1) and respective air quality effects to obtain necessary modeling parameters.

Our first modeling period represents the stand establishment phase at around year 3 of the project [Phase 1; leaf area index (LAI) = 3.17 and DBHs < 12.7 cm]. Our second modeling period characterizes a maturing stand at about year 20 to represent years 11–30 (Phase 2; LAI = 3.42 and DBHs ≥ 12.7 cm). To simplify our biophysical modeling, we assume that seedlings without a DBH will have similar growth and mortality rates as those trees with a DBH < 7.6 cm. Further, we assume that because of appropriate site preparation, planting criteria and monitoring, planting stock will become established within the first year of planting. Additional required modeling parameters were set at these values: Leaf dieback and missing crown, 80% and 10%, respectively, for both phases; tree condition = good, and percent crown present = 75, for both phases; and crown light exposure of 3 and 5, for phases 1 and 2, respectively.

To simplify our biogenic emission modeling, we estimate phase 1 and phase 2 VOC emissions for a growth-mortality modeled tree population of 244,456 (year 3) and 56,214 (year 20), respectively, for a reforestation project with an initial planting density of 730/ha (*SI Appendix*, Table S6.2). Although leaf biomass is usually the key forest structural parameter used for biogenic emission modeling (44, 64), due to the lack of leaf biomass allometric equations for our species we assume a linear relationship between leaf biomass and leaf area and develop leaf area-scaled VOC emission estimates (kilograms of VOC per square meter of tree cover) for other planting densities using modeled tree cover, DBH-based growth-mortality model estimates and the crown area equation (87), and VOC emission results from phases 1 and 2 (*SI Appendix*, section S6). Detailed UFORE modeling methods and assumptions can be found in refs. 32 and 76.

Finally, due to a lack of species- and region-specific allometric equations, we estimate individual tree aboveground carbon (AGC) storage using a composite equation for mixed hardwoods (91):

$$AGC = \exp(-2.48 + 2.4835 \times \ln\ DBH). \quad [2]$$

We derived annual net carbon sequestration as the year (t)-on-year difference in carbon storage during our analysis period, $AGC_t - AGC_{t-1}$.

Carbon Offsets. Reforestation projects in the United State are eligible for generating carbon offsets under California's US Forest Projects Offset Protocol if they are additional–that is, not otherwise required by law, regulation, or any legally binding mandate applicable in the offset project jurisdiction, and would not otherwise occur in a conservative business-as-usual scenario (35). Unlike the regulatory-prescribed conventional air pollution control technologies included in SIPs, emerging SIP measures like reforestation are not mandatory. Thus, we expect a reforestation project to meet the additionality requirement, except in cases where its cost effectiveness exceeds that of conventional control approaches sufficiently to make its implementation clearly profitable even without offsets.

We use the March 2012 price of \$12.25/t CO_2e (\$45/t C) for December 2013 forward contracts for guaranteed California Compliance Offset Credits (92) to calculate expected offset revenue. Offset prices have increased slightly during January 2012–January 2013 (93, 94), but we assume real offset prices will remain unchanged during our analysis period–likely a conservative assumption given the large current and expected future supply shortfall (95). We estimate offset quantity as aboveground tree carbon sequestered by the project minus the maximum 19% mandatory contribution to the CARB forest offset project buffer account (using US default fire risk of 4%; ref. 35).

Avoided SCC. Estimates of the SCC–the total value of the sum of future damages from a 1-t increase in atmospheric CO_2 concentrations–vary widely (96). We use the two "middle" SCC estimates developed by the federal Interagency Working Group on Social Cost of Carbon (97), which represent the averages of the damage estimates produced by the Dynamic Integrated Climate-Economy; Policy Analysis of the Greenhouse Effect; and Framework for Uncertainty, Negotiation and Distribution models (97) for discount rates (PRTP) of 3% and 2.5%. The SCC present value (2012) used to value aboveground carbon sequestered by our reforestation project declines from \$24.7 (3% PRTP) and \$40.1 (2.5%) respectively per ton of C in 2012 to \$18.4 and \$31.4/t in 2042 (*SI Appendix*, Table S10).

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The Honorable Eddie Bernice Johnson
Ranking Member, Committee on Science, Space, and Technology
U.S. House of Representatives

Dear Ranking Member Johnson:

Our nation has long worked together – red states and blue states alike – to help protect our communities and our families from harmful air pollution including the deleterious impacts of ground-level ozone (smog). I respectfully submit this information for consideration by the U.S. House of Representatives Science, Space, and Technology Committee at its March 17, 2015 hearing on the U.S. Environmental Protection Agency's proposed National Ambient Air Quality Standards for Ozone. Strengthening these vital air quality standards in accordance with medical science science is mandated by the nation's Clean Air Act, is foundational to ensure transparency and science-based rigor in telling American's whether their air is safe to breathe, and is essential to protect the health of our citizens including those who are especially vulnerable to the health harms from ozone air pollution.

Strengthened Ozone Standards are Achievable and Cost-Effective

Strengthened ozone standards are urgently needed to protect public health and many highly cost-effective, commonsense clean air measures are available to help secure these needed health protections. The 40-year history of the Clean Air Act shows that the nation's public health standards are achievable, through available technologies and innovation by states and businesses.

Our nation has often worked to achieve greater reductions than required, sooner, and at lower costs than estimated. Indeed, there are many clean air measures well underway that will help states, communities and families realize vital protections from ozone pollution.

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National headquarters New York · Austin · Boston · Boulder · Los Angeles · Raleigh · Sacramento · San Francisco *Project offices:* Beijing, China · Bentonville, AR

Misplaced "Sky is Falling" Claims Focus our Nation on Polarizing Scare Tactics Instead of the Clean Air Protections that are Needed for America's Communities and Families

Some claim that strengthening the ground-level ozone standard to protect public health, as the science and law demands, would amount to "the most expensive regulation ever."[1] Unfortunately, these "sky is falling" prognostications are not new. In 1997, during another debate over strengthened national public health standards, Senator Spencer Abraham (R-MI) was among those who claimed that the new standards would have serious economic impacts: "Dry cleaning establishments, hair salons, and other small businesses will not be able to absorb the increased costs imposed by these regulations," the Senator said.[2]

In fact, our nation made enormous strides in protecting public health from air pollution through commonsense cost-effective solutions. This is consistent with the time tested history of the Clean Air Act. Between 1990 and 2020, a recent EPA report projects that the benefits of the Clean Air Act will outweigh costs by 30 to 1.[3]

In recent years, similar "sky is falling" claims have been made about clean air standards to control acid rain, cut mercury and other air toxics, reduce soot, and lower tailpipe emissions. These "sky is falling" claims were recently prominent in the debate over EPA's landmark mercury and air toxics standards for power plants. EPA Administrator Lisa Jackson signed the final Mercury and Air Toxics Standards in December 2011 at Children's Hospital in Washington, D.C. Within months, major power companies that had been making "sky is falling" claims about the compliance costs during EPA's development of these standards were touting to investors that compliance costs were plummeting:

- On July 20, **American Electric Power CEO Nicholas Akins** confirmed that the company's projected costs have come down nearly 25% from what AEP originally projected. He added, "[W]e expect it to continue to be refined as we go forward." In other words, costs will come down even further.[4]

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[1] Nat'l Assoc. of Manuf., *Ozone Regulations: Potentially the Costliest Regulation in History Threatens Manufacturing Comeback*, http://www.nam.org/Issues/Ozone-Regulations/ (last visited Dec. 15, 2014).

[2] 143 CONG. REC. S10813 (daily ed. Oct. 9, 1997) (statement of Sen. Abraham).

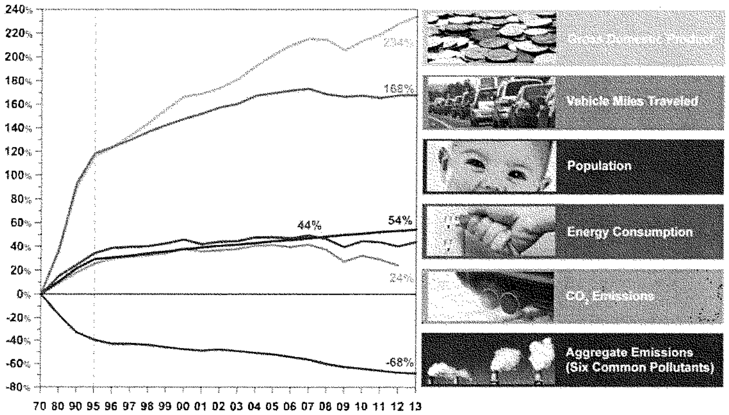
[3] U.S. Environmental Protection Agency, *The Benefits and Costs of the Clean Air Act from 1990 to 2020*.

[4] *Nicholas Akins, American Electric Power Co., Inc. Q2 2012 Earnings Call Transcript (July 20, 2012), available at* http://seekingalpha.com/article/736561-american-electric-power-management-discusses-q2-2012-results-earnings-call-transcript?all=true&find=american%2Belectric%2Bpower%2BAEP%2B%2Bjuly%2B12%2C%2B2012.

- On May 15, **Southern Company CFO and Executive Vice President Arthur P. Beatty** stated that the amount the company projects for compliance costs "could be $0.5 billion to $1 billion less, because of the new flexibility that [the company has] found in the final rules of the MATS regulation."[5]
- On August 8, **First Energy CEO Anthony Alexander** stated, "[W]e have significantly reduced our projected capital investment related to MATS compliance."[6]

Based on recent earnings calls, American Electric Power Company's range of cost estimates has fallen by a third to half, Southern Company's cost estimates have declined by a third, and FirstEnergy's costs have fallen approximately 77-85 percent.[7]

This is consistent with the history of the Clean Air Act. Since 1970, our nation has reduced the six pollutants regulated under the national ambient air quality standards program by 68 percent while GDP has grown 234 percent as illustrated in the graph below.



Source: EPA[8]

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[5] *Art Beattie, CFO of Southern Company, Deutsche Bank Clean Tech, Utilities and Power Conference Call Recording (May 15, 2012), available at http://earningscast.com/SO/20120515.*

[6] *Anthony Alexander, CEO, FirstEnergy, Q2 2012 Results, Earnings Call Transcript (Aug. 8, 2012), available at http://seekingalpha.com/article/790061-firstenergys-ceo-discusses-q2-2012-results-earnings-call-transcript.*

[7] *See* Envtl. Def. Fund, Blog, *Power Companies' Declining Estimates of Compliance Costs of the Mercury & Air Toxics Standards (MATS)*, http://blogs.edf.org/climate411/files/2014/05/Declining-costs-of-MATS-compliance.pdf?_ga=1.102810441.834084056.1418406109.

Actions Already Underway Will Help Communities Meet Strengthened Ozone Standards

Currently, 90 percent of areas designated nonattainment for the 1997 ozone health standards now meet those standards.[9] The U.S. has already taken steps over the past few years that help to cost-effectively reduce ozone smog pollution and help restore healthy air. Those protections include the Tier 3 tailpipe standards, supported by the U.S. auto industry, which will slash smog-forming pollution from new cars beginning in model year 2017 and the lower sulfur gasoline requirements will reduce pollution from every car on the road, and EPA's proposed Clean Power Plan which will substantially reduce smog-forming pollutants from power plant smokestacks nationwide.

These are just a few of the existing and pending national emission standards that will secure substantial reductions and that EPA anticipates will help to achieve broad-based compliance with strengthened ozone air quality standards. Analysis of various clean air measures adopted or soon to be put in place indicates that our nation will reduce the precursors to smog by millions of tons, securing over two million tons of volatile organic compound reductions and over five million tons of nitrogen oxides reductions.[10] These emissions standards will secure vital reductions that will help states restore healthy air for those communities and families afflicted by ozone pollution.

Thank you for your leadership and attention to this important issue.

Sincerely,

Vickie Patton

Vickie Patton
General Counsel
Environmental Defense Fund

---

[8] U.S. Environmental Protection Agency, Air Quality Trends, http://epa.gov/airtrends/images/y70_13.png (last visited Dec. 15, 2014).

[9] U.S. Environmental Protection Agency, *The National Ambient Air Quality Standards, EPA's Proposal to Update the Air Quality Standards for Ground-level Ozone*, Fact Sheet, *available at* http://www.epa.gov/airquality/ozonepollution/pdfs/20141125fs-numbers.pdf.

[10] U.S. Environmental Protection Agency, Regulatory Impact Analysis at tbl. 3-1.

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This corrected version of the editorial was posted on 12/29/14. The previous version included several values that were stated in ppm, rather than ppb.

Scientific Evidence Supports Stronger Limits on Ozone

In 2007, 2010, and now again in 2014, the American Thoracic Society (ATS) has recommended that the U.S. Environmental Protection Agency (EPA) adopt an 8-hour ozone national ambient air quality standard of 60 ppb in order to adequately protect public health(1, 2). While the recommended standard endorsed by ATS has not changed during this time, the scientific evidence supporting this recommendation has significantly strengthened. The scientific evidence available seven years ago justifying this recommendation has been supplemented by an even greater understanding of health effects of ozone exposures, including infant respiratory problems, worse childhood asthma control, reduced lung function, and increased mortality in adults.

On November 25, 2014, the EPA proposed a standard in the range of 65 to 70 ppb, which is lower than the current standard of 75 ppb[1]. While we applaud the EPA for proposing a stricter standard, we believe the scientific evidence clearly calls for a standard of 60 ppb to protect human health. We are currently in the public comment period for the proposed ozone rule and urge the EPA to issue a more protective standard of 60 ppb. This is the second time that the Obama Administration has reviewed the cnrrent ozone standard of 75 ppb. The previous administration established the current standard outside of the range recommended by the Clean Air Science Advisory Committee (CASAC) of 60 to 70 ppb(3). In 2010, CASAC reaffirmed its initial recommendation as part of an early reassessment the ozone standard, an effort that was ultimately abandoned in 2011(4). Since a new science assessment was not conducted as part of that review, the current review of the ozone standard is the first to consider new scientific evidence since 2006.

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[1] The standard is defined as the annual 4th highest maximum daily 8-hour ozone average, averaged over three years

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Since 2006, much more evidence has accumulated that ozone exposures in the range of 60 to 75 ppb have adverse physiologic effects across the entire age spectrum—from infants to older adults. While there is also some evidence of health effects of ozone exposure below 60 ppb, the strongest evidence supports the conclusion that serious adverse health effects occur across all ages at levels above 60 ppb.

Highlights of this new body of evidence include a study of emergency department visits among children aged 0 to 4 in Atlanta, which found that each 30 ppb increase in the 3-day average of ozone was associated with an 8% higher risk of pneumonia and a 4% higher risk for upper respiratory infection(5). Several studies have demonstrated dose-response relationships between ozone exposure and childhood asthma admissions at exposure levels in the 60 to 80 ppb range (6–9). Similar associations have been found for adult admissions for asthma(9–11) and COPD(12, 13). A population-based cohort study of generally healthy adults found that FEV_1 was 56 mL lower after days when ambient ozone ranged from 59 to 75 ppb compared to days with levels under 59 ppb(14). Controlled human exposure studies have re-affirmed lung function decrements in healthy adults after exposure to 60 to 70 ppb of ozone(15, 16). Perhaps of greatest concern, there is now stronger evidence of increased mortality in association with ozone(17–19), particularly among the elderly and those with chronic disease(20, 21).

In making this recommendation, we acknowledge that challenges exist in reducing ambient ozone concentrations. Unlike other pollutants regulated by the Clean Air Act, ozone is a secondary pollutant formed from precursor pollutants through photochemical reactions in the atmosphere. This presents challenges in designing successful abatement plans. For example, the natural presence of precursor chemicals, and long-range transport of ozone from beyond US jurisdictional boundaries, can each contribute to background ozone levels(22). However, the

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adverse health effects of ozone do not discriminate based on the source of precursor pollutants, nor do these complexities change the reality that serious adverse health effects occur at concentrations above 60 ppb. While the science surrounding background ozone is still emerging, the evidence of adverse health risks of ozone is clear.

Another challenge for ozone management is that the secondary formation of ozone can result in higher concentrations downwind from the primary sources of precursor pollutants, cutting across jurisdictions. As a result, integrated planning across jurisdictional boundaries and compliance with the "good neighbor" provision of the Clean Air Act will be necessary to reduce regional ozone to levels that adequately protect public health(23).

While controlling ambient ozone will be a challenge, it will also present opportunities for innovation and leadership. State Implementation Plans will vary in how counties across the U.S. plan to remediate unhealthy levels of ozone. While all plans will take time to achieve the needed results, the best approaches will be identified and serve as a model that other regions can follow to protect public health.

The timing is excellent for revision of the ozone standard to 60 ppb as the new standard can build on substantial recent progress. In March 2014, the EPA finalized new standards for motor vehicle emissions and cleaner fuels which are expected to reduce ozone levels significantly(24). Already-adopted revisions to standards for particulate matter and air toxics are also likely to further reduce ozone formation(25). But above all, we are entering an era of technological innovation, infrastructure reconstruction, and commitment to sustainability in which obsolete technologies are being replaced by more efficient and less-polluting innovations. This is exactly the right time to lay down the correct performance criteria and design

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specifications for the new technology, before we commit to a new energy and transportation regime that could limit our choices in the future.

The US EPA has taken significant actions in the past when justified by scientific evidence, most notably by reducing the permissible concentrations of airborne lead by 90% in 2008 and reducing the permissible annual concentrations of fine particle pollution by 20% in 2013(26). We encourage the EPA Administrator, with the full support of the President, to acknowledge the large body of scientific evidence documenting the harms caused by ozone pollution and set a standard of 60 ppb to protect the health of the American public.

Mary B. Rice M.D.
Division of Pulmonary, Critical Care and Sleep Medicine
Beth Israel Deaconess Medical Center, Boston, Massachusetts

Tee L. Guidotti M.D. M.P.H. D.A.B.T.
Fulbright Visiting Research Chair
Institute for Science, Society and Policy
University of Ottawa, Ottawa, Ontario, Canada

Kevin R. Cromar Ph.D.
Department of Environmental Medicine
New York University School of Medicine, New York, New York

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On behalf of the ATS Environmental Health Policy Committee.

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JOHNS HOPKINS
UNIVERSITY

Department of Pediatrics
School of Medicine / CMSC 1102
The Johns Hopkins Hospital / Baltimore, MD 21287-3923
(410) 955-5883 / FAX (410) 955-0229
Division of Immunology and Allergy

March 9, 2015

The Honorable Suzanne Bonamici
Ranking Member, Environment Subcommittee, House Science, Space and Technology Committee
2321 Rayburn House Office Building
Washington, D.C. 20515

Dear Congresswoman Bonamici,

We are writing to give more information and perspective about our recent publication "Neighborhood poverty, urban residence, race/ethnicity, and asthma: Rethinking the inner-city asthma epidemic" and its implications for the relationship between asthma and air pollution.

In this study we used data from the National Health Interview Survey (NHIS) to examine the relationship between metropolitan status (i.e., living in an Urban, Suburban, Medium Metro or Small Metro/Rural area), poverty, race/ethnicity, and prevalence of asthma among children in the U.S. This survey, conducted by the Centers for Disease Control is a nationally representative sample. In our study we found that poverty and race/ethnicity were major risk factors for asthma prevalence, but that living in an urban metropolitan area was not a risk factor for asthma prevalence. This study's finding has been misinterpreted by some who believe that it suggests that air pollution in general, and ozone in particular, is not important for asthma[i].

This is an erroneous conclusion to draw from the study's results because first, our study did not examine air pollution, and second, residence in an urban area cannot be taken as a surrogate for high air pollution exposure, as air pollution is not confined to urban areas. In fact, ozone levels are actually highest in suburban areas downwind from urban areas rather than in urban areas themselves[ii], and there is substantial variability across the U.S. between regions and areas. For example, air pollution levels are very high in non-urban areas in the California Central Valley. Most importantly, a link between ozone levels and respiratory health outcomes is supported by many studies that have used a variety of methods that are more appropriate for this question[iii].

Our findings instead highlight that children with asthma live in all types of metropolitan areas throughout the U.S., and suggest the need for comprehensive policies to reduce the prevalence of asthma across the U.S. Until we can develop such policies, we need to reduce threats to the health of people with asthma, including ozone pollution.

Thank you for your interest in this matter. Please contact me with any questions.

Sincerely,

Corinne A. Keet, MD, PhD
Assistant Professor of Pediatrics
Johns Hopkins School of Medicine
Baltimore, MD 21287
Email: ckeet1@jhmi.edu
Phone: 410-955-5883

On behalf of my co-authors:
Meredith McCormack, MD, MHS, Johns Hopkins School of Medicine
Roger D. Peng, PhD, Johns Hopkins School of Public Health
Craig Pollack, MD, MHS, Johns Hopkins School of Medicine
Emily McGowan, MD, Johns Hopkins School of Medicine
Elizabeth C. Matsui, MD, MHS, Johns Hopkins School of Medicine

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[i] For example: http://instituteforenergyresearch.org/analysis/study-undermines-scientific-basis-epas-ozone-rule/

[ii] Simon, H et al. Environmental Science and Technology. 2015, 49, 186-195

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Kim CS et al. Am J Respir Crit Care Med. 2011, 183:1215-1221.
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Rice MB et al. Am J Respir Crit Care Med. 2013. 188(11): 1351-1357

SUBMITTED BY REPRESENTATIVE SUZANNE BONAMICI

March 17, 2015

The Honorable Gina McCarthy
Administrator
U.S. Environmental Protection Agency
EPA Docket Center Mailcode 28221T
1200 Pennsylvania Avenue, NW.
Washington, DC 20460

Attention Docket ID No. EPA-HQ-OAR-2008-0699

Dear Administrator McCarthy:

We, the undersigned, are public health and medical professionals who call on you to protect our patients, our communities and our nation from ozone pollution by adopting the most protective national ambient air quality standard of 60 parts per billion (ppb).

The Clean Air Act requires the U.S. Environmental Protection Agency (EPA) to set the primary national air quality standard to accurately reflect the state of the science and to protect the public health, including those most vulnerable to the effects of air pollution, with an adequate margin of safety. There is a robust body of scientific evidence that supports the adoption of a more protective standard of 60 ppb. Clearly, the evidence show that the current standard of 75 ppb does not protect the public health.

EPA's panel of expert science advisors, the Clean Air Scientific Advisory Committee (CASAC), has reviewed the scientific evidence in the EPA Integrated Science Assessment, the Health Risk and Exposure Assessment and the Policy Assessment and has unanimously concluded that "there is clear scientific support for the need to revise the standard." We also agree with CASAC's unanimous expert opinion that at "70 ppb there is substantial scientific evidence of adverse effects," and that adopting a standard of 60 parts per billion "would certainly offer more public health protection than the levels of 70 ppb or 65 ppb and would provide an adequate margin of safety." (CASAC letter to Administrator McCarthy, dated June 26, 2014).

Controlled human exposure studies have repeatedly demonstrated that some healthy adults experienced reduced lung function and increased airway inflammation following exposures to concentrations of 60 ppb and below (Adams, 2002 and Adams, 2006 Brown et al., 2008 and Kim et al, 2011). The chamber studies establish the strongest evidence that concentrations above 60 ppb provide significant risk not only to many healthy adults, but most critically, to vulnerable and susceptible populations, including children, seniors and people with asthma and other chronic lung diseases.

Six large epidemiological studies in the U.S. and Canada provide further real-world evidence that a standard of either 70 ppb or 65 ppb fails to provide adequate protection, as recognized in the Policy Assessment. These studies (Bell et al., 2006; Cakmak et al., 2006; Dales et al., 2006; Katsouyanni et al., 2009, Stieb et al, 2009) reported positive and statistically significant associations from the most serious health threat—premature death—as well as from hospital admissions and emergency department visits. In the majority of locations where increased risk was found, the ozone levels would have met the weaker standards of either 70 or 65 ppb, but would not meet a standard set at 60 ppb.

The combined evidence demonstrates that the EPA's proposed range of 65 to 70 ppb would not provide adequate protection for the large at-risk populations, nor even for all healthy adults. EPA's *Integrated Science Assessment* identifies children, the elderly, outdoor workers and people with asthma as more susceptible to ozone than the general population. However, EPA also identified research that indicated that others, including people with low socioeconomic status, may face increased risk.

The primary ozone standard is crucial to protecting the public health. The current ozone standard clearly puts far too many people at risk. Therefore, we urge you to adopt the most protective level for the ozone national ambient air quality standard of 60 parts per billion.

Sincerely,

Alabama
A. David Russakoff, MD
Angela Garnett, LPN
DeNay Kirkpatrick, DNP
Donna Shanklin, MPH
Marissa Natelson Love, MD
Mark Dransfield, MD
Melanie Dickens, MS
Paula Warren, MD
Selena Coleman, MPH
Stacie Propst, PhD
Surya Bhatt, MD
Tammy Shikany, RRT
Tim Op't Holt, RRT

Alaska
Deborah Giedosh, Ed D, RN
Debra Riner, RN, BSN
Elizabeth Snyder, PhD, MPH
Erin Michael, RN, MSN, BA, ADN
Gretchen Clarke, MPH
Lonni Clayton, RRT, AE-C
Susi Peterson, RN

Arizona
Alan Crawford, MBA, RRT-NPS-ACCS, AE-C, HACP
Barbara Warren, MD, MPH, FACP
Bernice Carver, BA, Public Health Educator
Beth Roberts, RRT-NPS, RCP
Cassalyn David, MPH
Corinthia Walters, MSHE, RRT, AE-C
David Sanderson, MD
David Wootten, BS, RRT
Dena L'Heureux, MD
Diane Lupo, RRT
Donna Bryson, RN
Eve Shapiro, MD
George Parides, DO
Jennifer Miller, BA, RRT
Jill Triplett, RRT
Jim Love, RRT
John McKinney, RRT
Keith Kaback, MD
Leah Iverson, MPH
Mary Ellen Westlake, RRT
Patricia Van Maanen, RN, BSN, MS
Phyllis Primas, RN, BSN, MPH, PhD
Rafael Merle, RRT, RPFT, MS, NPS
Rob Rachowiecki, RRT, MS
Robin Rosenberg, RRT
Rolf Halden, PhD
Tony Corrales, RRT

Arkansas
David Grimes, MD, MPH
James Wohlleb, MS
Nathaniel Smith, MD, MPH
Page Daniel, MS
Syed Abid, MD

California

Adriana Botic, MPH Candidate
Akilina Douthat, BSPH
Amanda Gonzales, MPH
Amy D Kyle, PhD MPH
Ana Gomez, VN
Andrea Graboff, PT
Andrew Deckert, MD, MPH
Angela Wang, MD
Angelie Soriano, LVN
Angelie Soriano, LVN
Anne Kelsey Lamb, MPH
Anya Gutman, MPH
Armando Valdez, PhD
Arnold Gorske, MD
Barbara Langham, RN, BSN
Barbara O'Malley, RN
Catherine Thomsen, MPH
Christopher Chin, DO
Christopher Warren, PhD Student
Chung Yi, RRT
Cindy Nelson, RN, PNP, MPH
Cindy Russell, Cindy Russell, MD
Consuelo Pernia, CHP
Dan Huynh, MPH
Dan Woo, MPH
David Cooke, MD, FACS
David Pepper, MD
Dawn Mare Wadle, MD
Deanna Aikenberry, MPH
Deborah Baker, RN
Deborah Baker, RN
Diana McKee, RRT
Don Gaede, MD
Donna Carr, MD
Dr. Brent Green, PhD, MPH
Elaine Lo, MPH
Elena Lingas, DrPH, MPH
Erica Kasper, MD
Eugene Takahashi, PhD, MPH
Fred Herskowitz, MD
G. Zacharia Reagle, DO
Gail Hovland, RRT
Gilbert Urquidez, RRT
Greg Urbina, RN
Gregory Stevens, PhD
H. Leabah Winter, MS, MPH, MPH
Hassan Bencheqroun, MD
Ivan Gomez, MD, MS
Janene Harper, RRT
Janyth Bolden, RRT
Jennifer Akamine, MD
Jerena Hammett, RRT, RCP
Jill Biggane, RN
Jo Elliff, RN, PHN, FNP
Joan Edelstein, MSN, DrPH, RN, PHN
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Jose Ramon Fernandez-Pena, MD, MPA
Jose Vempilly, MD
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Kate Cheyne, MPH
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Marie Hoemke, RN, PHN
Marilia Baltazar, RN
Mark Andrade, RRT
Mark Horton, MD, MSPH

California, continued

Mark Shane Balagot, RRT
Mary Frazier, RN, MSN, AE-C
Mary Hunsader, RN, MSN, CNS, AE-C
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William Wallin, MD
Yong Sun, RRT

Colorado

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Sara Pope, CNA
Sonya Pradia, RRT
Timothy Kennedy, MD

Connecticut

Audrey Fee RRT
Christina Kyriakos MPH

Connecticut, continued

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Connie Dills RRT
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Delaware

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Florida

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Georgia

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Hawaii
Christian Gloria, PhD, CHES
Christine Fukui, MD
Stephen Wehrman, RRT, RPFT
Valerie Chang, JD, facilitator of COPD Support Groups

Idaho
Judi Jackson, RRT
Judith Bailey-Jackson, RRT

Illinois
Alfreda Beth, PhD
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Angel Perry, MPH student
Bernadette McCoy, CRT
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Cheryl Davis, RN
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Worku Feleke, MPH
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Indiana
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Iowa
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Katie Jones, MPH, CHES
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Kansas
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Marshall Post, RRT
Mashall L. Post, RRT
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Kentucky
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Louisiana
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Kyle Happel, MD
Marcia Oursler, MPH
Nereida Parada, MD
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Maine
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Albert Nickerson, LA
Allen Wicken, PT
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Bonita Irwin, LPN, AE-C, CTTS
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Wellness & Health
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Lawrence Fischman, MD
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Maine, continued

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Pierre Marki, RRT
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Massachusetts

Angeli Jesrani, RRT
Ann Ottalagana, PTA
Antonia Blinn, BS, CHES
Bethany Schloss, RRT
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Linda Kovitch, RRT, DRNA, MSN
Lisa Tonello, FFS facilitator
Lois McCloskey, DrPH
Malcolm Bryant, MD MPH
Mary Vogel, JD
Nahiris Bahamon, Medical Student
Philip O'Donnell, CRT
Ron Raymond, RRT
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Stephanie Beaudett, BS Nursing, MEd, NCSN
Susan Lundin, RN, BSN, AE-C

Michigan

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Cheryl Holloway, PhD PhD
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Dave Errickson, RN
Dave Gupta, MD
Delbert Raymond, PhD, RN
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Dilhara Muthukuda, MPH

Michigan, continued
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Kathleen Slonager, RN
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Minnesota
Annette Schmit-Cline, MD
Borgstrom Kim, RRT
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Cherie Zachary, MD
Cheryl Sasse, RRT
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David Midthun, MD
Dona Haines, RN, PHN
Eamon Flynn, MPH
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Janet Malkiewicz, RN, AE-C
Jessica Simmons, RRT, CPFT, AE-C
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Mary Ruff, RRT
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Sandra Kistner, RRT
Sonja Johnson, RN, BSN, PHN
Sumathi Vaidhyanathaswamy, MD
Teresa Schicker, MPA
Travis Anderson, MS

Mississippi
Brenda Bell Caffee, MPH
Celia Roberts, RN student
Jennifer Cofer, MPH, CHES
Marshae McNeal, MPH
Ron Davis, MBA
Stephanie Watson, RRT
Trisha Neumeier, RN

Missouri
Ajay Sheshadri, MD, MSCI
April Fritz, BSRT
Debbie Hoehn, RNC WHNP
Jaime Tarsi, RN, MPH
Laura Frick, MSW
Michelle Robinette, MD/PhD student
Shahida Rice, MPH

Montana
Christine Stanish, RRT
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Elizabeth Schenk, PhD, MHI, RN
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Mark Robertson, MSPT
Meg Traci, PhS
Paul Smith, DO
Robert Byron, MD, MPH
Robert Merchant, MD

Nebraska
David Corbin, PhD

Nebraska, continued
Marlene Wilken, RN, MN, PhD
Ryan Schmidt, RRT

Nevada
Aimee Barnes, BSRT, RRT
Angelina Manchester, MSN, RN
Cecilia Degenhart, MEd; RRT
Douglas Springer, CRT
Hermine Plotnick, OTR
Holly Cechvala, BSRC, RRT-NPS
Janera Tucker CADC
Joseph Iser MD, DrPH, MSc
Kyle Thrower, FFS facilitator
Laura O'Gara, BSW
Lysa Buonanno, BSRS, RT(R)
Mayra Burnham, BA
Paul Visone, CRT
Sierra McKillips, CAN

New Hampshire
Amy Hibbard, ACSM - Certified Exercise Physiologist
Ann Turner, MS, RN, CCM
Anne Duszny, RRT,NPS, AE-C
Barbara Gleason, RN BSN AEC
Cheryl Keeler, CMA
Christine Houle, LPN
Jessie Lawford, RRT
Katherine Wescott, RN
Kristie Stone, LPN, AE-C, VA-BC, ROT
Lindo Terry Spencer, MD
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Virginia Hedberg, RN
Xan Gallup RN, RRT, AE-C

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Mary Stabile, CHT
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Natalie Pierro, RN
Nicolette Crescas, RN, MPA
Nimfa Cabatingan, RN
Roni Todd-Marino, LPC
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Susan Landick, BS, RRT
Tommie Lou Judson, RN
Velva Dawson, MPA
Zachary Ehrlich, MPH

New Mexico
Akshay Sood MD, MPH
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Duane Ross, MD
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Kathleen Moseley, RN MS
Rachel Seltzer, MD, MPH

New York
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Allen Dozor, MD
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Anne Little, MPH, AE-C
Anne Lopez, RD, CDE
Arianny Tejada, MPH
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Barbara Warren, RN, MS
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Catherine Machalaba, MPH
Christian P Becker, RRT
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Cindy Trubisky, AE-C
Colleen Lynch, MD
Cynthia Rosen, AE-C

New York, continued

Daniel Jacobsen, NP-C
Daniel Nadelman, FFS Facilitator
Darcy Pitcheralle, RRT
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Debra Weintraub, RN MSN
Diane Petito, RN, MSN, CPNP, AE-C
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Gary Weinstock, MD
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Heather Calendrillo, CPNP
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Jennifer Sullivan, MS
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Kathleen Sheehan, RN
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Mary Cataletto, MD
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Maya Korin, PhD, MS
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Michael Richheimer, MD
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Nathaniel Speer, RN
Neil Schachter, MD
Nikki Vivion, MPH
Noah Greenspan, DPT, CCS, EMT-B
Norman Edelman, MD
Richard Collens, MD
Richard Novitch, MD
Sarah Enteen, FFS facilitator, MPH(c)
Sarah Sidhu, MD
Sheila Palevsky, MD MPH
Sonja Mains, PT
Stacie Lampkin, PharmD
Susan Rappaport, MPH
Sybilla Daniel Douglas, MSN, RN, AE-C
Taisy Conk, MPH
Tara O'donohue, MD
Thomas Frederick, RN
William Browne, RTT, AE-C CRT, AE-C
Zachary Peters, MPH

North Carolina

Gregg Stave, MD, JD, MPH
Karin Yeatts, PhD, Epidemiology
Laura Kellogg, RN, AE-C
Lisa Johnson, RRT, RCP, BAS, AE-C
Lisa Moyer, Pediatric RN
Masa Reaves, BSW
Nicolle Hawley, RN
Peggy Spivey, RN
Rebecca Geary, RN, BSN
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North Dakota

Becky Anderson, RRT
Chelsea Bryant, MPH
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Erin Dionne, RRT
Herbert Wilson, MD
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Jay Taylor, RRT, TTS
Monica Paulo, MD

Ohio

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Amy Chuang, MD
Amy Pellegrini, RRT-NPS, CPFT
Benjamin Kopp, MD, FAAP
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Oklahoma

Bradon Nave, RRT
Marshan Marick, MPH
Polly Robinson, PharmD

Oregon

Annee von Borg, MSW, MPH MSW, MPH
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Brenda Batts, MPH, RRT, NPS
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Susan Piekarski, CRT

Pennsylvania

Alana Wright, MSHA/MSHE
Alicia McKelvey, MD
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Azael Hernandez, RRT, RPFT
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Clarke Woods, RRT
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Deborah Gentile, MD
Dolores Minchhoff, DNP
Emma Watson, MPH
Gary Emmett, MD FAAP
Gisoo Ghaffari, MD
Gopal Sankaran, MD, DrPH
Helen Podgainy, MD
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Joe DiSanto, BS PHE
John Esbenshade, CRT
Kari Magill, RRT
Kate Niehoff, MD
Kristin Jaros, RRT CPFT
Lacreasia Wheat-Hitchings, MD, MPH
Laura Loggi, RRT
Lauren Reichbaum, RRT
Lenore Resick, CRNP, FNP-BC
Lyubov Gayevaya, CRT
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Matthew Dietz, MPH
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Maureen Romano, RRT
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Monica Lazur, MPH
Nicholas Thompson, MPHc
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Oscar Mayer, MD
Poune Saberi MD, MPH

Pennsylvania, continued

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Rhode Island

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Patricia A. Nolan, MD, MPH
Phyllis Shier BA, RRT-NPS, CPFT
Renee Chartier, RRT
Terrance Healey, MD

South Carolina

Bailey Pierce, BS, Health Promotion
Cheryl Johnson Benjamin, MBA
Christine Power, RN
Dawn Pender, MSN, FNP
Hannah Corre, CHES, MA
Jan Eberth, PhD
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Kathy Biggs, MSPT
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South Dakota

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Joseph Spader, RRT
Peter Vitiello, PhD

Tennessee

Andres Carrion, MD
Anthony DeLucia, Ph D
Lacey Snell, RRT-NPS
Molly Meinbresse, MPH
Wilson McGriff, OD, MPH

Texas

Betty Chern-Hughes, RN, CNM, APRN
Harold Farber, MD, MSPH
Lisa Stone, MPH
Maria Colon-Gonzalez, MD
Marian Morris, MPH, RN
Onyinye Chukwuneke, MBA
Patricia Brooks, MED, MS
Wendy Benedict, MHA

Utah

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Dexter Pearce, MBA
Mimi Ujiie, MPPM
R. Scott Poppen, MD, MPA
Richard Kanner, MD
Sharon Moon, RN, BSN, MN

Vermont

Donohue Andria, BSN
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Richard Valentinetti, MPH
Eoana Sturges, MPH
Joan Dusablon, CRT
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Lewis Holmes, MD, MPH
Sarah Cosgrove, RRT, M-TTS, AE-C
Theodore Marcy, MD, MPH

Virginia

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Amy Paulson, MPH, AE-C
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Barbara Kaplan, MPH
Catherine Chandler, MHA, CHES
Danny Murphy, MPHc
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Robert Leek, MHA
Rotesha Colbert, PNP
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Samantha Ahdoot, MD
Sarah Jawaid, PharmD
Sarah Southard, CPPNP, AE-C
Sue Bhati, FNP-BC, PhD
Teresa Polk, RN, MSA
Virginia Weisz, PhD, WHNP

Washington

Aileen Gagney, MA, HHS, GA-C, DST, CLR,
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Jasmine Hutchinson, MSPH
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Diane Nichols, RRT
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Gary Johnson, BSHSM, RRT
Georgia Narsavage, PhD,MSN, Adult NP- BC
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Susan Aufdenkampe, RRT

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Allison Simon, CNA
Amy Kalkbrenner, PhD MPH
Amy Setchell, RRT and BS
Ani Saryan, MD
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Anne Weirich, RN
Asriani Chiu, MD
Barbara J. Ludke, MSN, RN
Betty Koepsel, BSN, RN-BC
Bonnie Rode, RN Student
Carol Arnold, RN
Chad Hess, RN
Christina Goff, RN Student
Clara Wittman, RN Student
Dawn Alberts, BSN, RN-BC
Deb Bakakarski, RRT
Deborah Grayson, RN, MSN, MPH
Diana Carroll, BS, RRT, AE-C
Diana Haley RN, BSN
Dion Porter, RN
Douglas Wubben, RN
Elizabeth Gore, MD

Wisconsin, continued

Elly Fatehi, PharmD
Eric Tourbier, RN Student
Erika Horstmann, PharmD
Heidi Lindroth, RN Student
Heidi Zafra, MD
Jane Shabtaie, RN
Jane Swoboda, RRT
Jennifer Bayuk Yednock, RN
Jennifer Cacciotti, RN Student
Jennifer Jansen, RN, BSN, MS
Jennifer Woo, MPH
Jessa Van Every, CHES
Jim Steinhoff, MT (ASCP)
Jo Ann Wagner Novak, MS, APNP
Jodi Jaeger, BS RRT-NPS
Joshua Steinberg, MD
Juan P. Ruiz, MD
Judith Komblatt, RN Student
Julie Tittl, RN, BSN
Kate Wilson, Master of Arts
Katelynne Klein, RN Student
Kathleen Roebber, MA, BSN
Kathryn Lammers, PhD, RN
Kevin McCabe, MD
Kirsten Berge, RN, OCN
Kristen Grimes, MAOM, MCHES
Kyle Martin, MD
Laura Wojtak, RN Student
Laurie Hartjes, PhD, RN
Linda Newberry-Ferguson, RN, BSN, MHS
Lisa Crandall, MSN
Liz Zeps, RN, BSN
Marlena Anderson, RN, BSN
Mary Biebl-Yahnke, BS, RRT, RPFT
Mary Koller, BSN
Matthew Gray, MD, MS
Megan Leadholm, Medical Assistant
Michael Jaeger, MD
Michael Lischak, MD
Michele Pettit, MPH, PhD, MCHES
Mitchell Grayson, MD
Monica Holmes, RN Student
Neal Cragg, BSN, RN
Nicole Carnegie, PhD
Omoshalewa Bamkole, CHW
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Patricia Bolling, MSN
Patricia Safavi, MD
Peggy Fritsch, RN
Randolph Lipchik, MD, MPH
Rebecca Hamann, RN Student
Rhonda Duerst, RRT-NPS
Rhonda Hertwig, PNP
Rose Aird, RN
Roxanne Hemmerling, RN, BSN, NCSN
Sara Lowe, APNP
Sarah Brundidge, RRT
Scott Peschke, MD, FAAFP
Shane Sanderson, MS, JD, REHS
Steven Brown, MD MD
Susan Ashton, BSN, retired
Susan Freese, RN
TeAngelo Cargile Jr., CHW
Teresa Prattke, MSN, WHNP-BC
Timothy Banwell, MPH
Todd Mahr, MD
Vanessa Witkowski, ADN, RN

Wyoming

Alex Bowler, MPH

Submitted by Representative Jim Bridenstine

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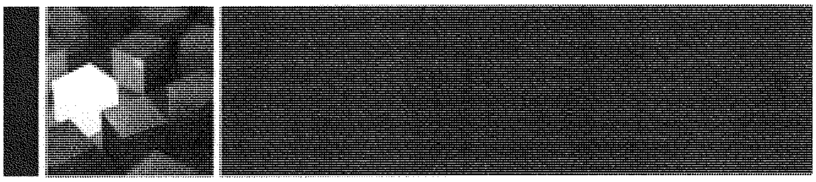
Economic Impacts of a 65 ppb National Ambient Air Quality Standard for Ozone

Executive Summary



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National Association of Manufacturers

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Project Directors

David Harrison, Jr., Ph.D.
Anne E. Smith, Ph.D.

Project Team

Scott Bloomberg
Sugandha Tuladhar, Ph.D.
Andrew Stuntz
Conor Coughlin
Julia Greenberger
Carl McPherson
Christopher D'Angelo
Mei Yuan, Ph.D.

NERA Economic Consulting

200 Clarendon St, 11th Floor
Boston, Massachusetts 02116
Tel: +1 617 927 4500
Fax: +1 617 927 4501

1255 23^{rd} St, NW, Suite 600
Washington, D.C. 20037
Tel: +1 202 466 3510
Fax: +1 202 466 3605

www.nera.com

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EXECUTIVE SUMMARY

This study evaluates the potential compliance costs and impacts on the U.S. economy if the U.S. Environmental Protection Agency (EPA) were to set a National Ambient Air Quality Standard (NAAQS) for ozone of 65 parts per billion (ppb). Employing our integrated energy-economic macroeconomic model (N_{ew}ERA), we estimate that the potential emissions control costs could reduce U.S. Gross Domestic Product (GDP) by about $140 billion per year on average over the period from 2017 through 2040 and by about $1.7 trillion over that period in present value terms.[1] The potential labor market impacts represent an average annual loss employment income equivalent to 1.4 million jobs (*i.e.*, job-equivalents).[2]

These results represent updated values from the results in our July 2014 report (NERA 2014), which developed estimates of the potential costs and economic impacts of achieving a 60 ppb ozone standard using the best information then available. In November 2014, the U.S. Environmental Protection Agency (EPA) released updated emissions and cost information supporting their proposal to revise the ozone standard (EPA 2014a); we have used that new information to update our analysis. Also, given that the proposed rule suggests setting a revised ozone NAAQS in the range of 65 ppb to 70 ppb, in this update we assess the economic impacts of a potential 65 ppb ozone NAAQS. This Executive Summary of our study begins with a summary of the differences between the information and methodology in our July 2014 report and those used in this updated study. It then provides summaries of our estimates of the costs and economic impacts of attaining a potential ozone NAAQS of 65 ppb.

Changes in Data and Methodology Since the July 2014 Report

The methodology used for this study is largely similar to the methodology used in our July 2014 report. This section discusses changes to the three components of our analysis:

1. *The methodology for estimating emission reductions.* This study used updated EPA information on the future NO_X and VOC emissions levels needed to comply with a potential 65 ppb standard (rather than a 60 ppb standard as in our July 2014 report).

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[1] All dollar values in this report are in 2014 dollars unless otherwise noted. The present value reflects impacts from 2017 through 2040, as of 2014 discounted at a 5% real discount rate; this discount rate falls in the 3% to 7% range recommended in EPA's *Guidelines for Preparing Economic Analyses* (2010a, p. 6-19), and it is consistent with the discount rate used in the N_{ew}ERA model.

[2] "Job-equivalents" is defined as total labor income change divided by the average annual income per job. This measure does not represent a projection of numbers of workers that may need to change jobs and/or be unemployed, as some or all of the loss could be spread across workers who remain employed, thereby impacting many more that 1.4 million workers, but with lesser impacts per worker.

Additionally, we used updated cost and effectiveness information about emission controls that have been identified by EPA.

2. *The methodology for estimating compliance costs.* We updated the costs of the known controls that EPA identified to attain the 65 ppb standard using EPA's new cost data. However, even for a 65 ppb standard, more than half of the emissions reductions needed across the country would come from measures that EPA still has not identified. Using the same evidence-based approach for developing a cost curve that we used in our July analysis (but using the more recent inventory data, and updating the calculations for a later year of compliance spending), we calculated the costs of the set of further emissions reduction needs that EPA has left unidentified in its current analysis. We also updated all dollar figures from 2013 to 2014 dollars.

3. *The methodology for estimating economic impacts.* We used the same version of NERA's $\mathrm{N_{ew}ERA}$ macroeconomic model as our previous study to estimate the economic impacts of our estimated costs for reducing emissions in the amount necessary to attain a 65 ppb ozone standard. In contrast to EPA's analysis, we excluded the proposed EPA Clean Power Plan rule from our modeling baseline.

In our July 2014 report, we performed a sensitivity analysis on the possibility that nonattainment, especially in rural areas of the U.S., could create barriers to continued growth in oil and gas extraction. A national policy question that remains in a state of flux is whether or not new permitting requirements hinder growth in energy production. A tightened ozone standard has the potential to cause nonattainment areas to expand into relatively rural areas, where there are few or no existing emissions sources that could be controlled to offset increased emissions from new activity. If nonattainment expands into rural areas that are active in U.S. oil and gas extraction, a shortage of potential offsets may translate into a significant barrier to obtaining permits for the new wells and pipelines needed to expand (or even maintain) our domestic oil and gas production levels. The sensitivity analysis in our July 2014 report resulted in much larger natural gas price effects, and raised macroeconomic impacts of our base case by about 30 to 50%. Limitations of time have prevented us from conducting a similar sensitivity analysis for this update.

Methodology for Estimating Emission Reductions

The July 2014 report relied on projected 2018 baseline VOC and NO_X emissions and EPA information from its 2008 and 2010 Regulatory Impact Analyses (RIAs) to estimate reductions required for all regions of the U.S. to come into compliance with a 60 ppb standard. The updated EPA information that we rely on in this study includes projected 2018 and 2025 base case and baseline emissions as well as EPA's estimates of reductions required from the 2025 baseline emissions to achieve a 65 ppb standard (EPA 2014a-g). We use the updated EPA estimates of state-by-state emissions reductions from the 2025 baseline as the principal basis for our estimates of NO_X emissions levels that would allow a 65 ppb standard to be attained nationwide.[3] In order to reach and maintain this level of NO_X emissions consistent with a 65 ppb ozone concentration, states would need to reduce emissions at existing sources and prevent any *net* increases in emissions from new or expanded sources. We also rely on EPA's revised data on the cost of emissions reductions for "known" control measures, which are provided by source sector and state.

Our methodology for estimating costs of emission reductions is similar to our July 2014 study. In both studies, we substituted our base case estimates of electricity generating unit (EGU) emissions for those of EPA, for consistency with our economic impact model, which estimates costs from EGU emissions reductions endogenously. As before, we adopted EPA's cost estimates for those controls that EPA identifies as "known"—that is specific controls for which EPA had developed emission reduction and cost information—and we applied our own more evidence-based approach for estimating costs for the many required reductions that EPA treats as "unknown." For estimating the impacts to the U.S. economy of our estimates of compliance costs, we assigned each state's projected cost to specific calendar years, using assessments of their likely attainment dates. Also consistent with our prior study, we assigned the costs to specific sectors in each state; for the "known" control measures these assignments were based on the sector-specific information available in EPA's data and for the "unknown" control measures, these assignments were based on emissions inventory data on the relative contribution of each source category to the remaining emissions in each state.

Methodology for Estimating Compliance Costs

Our methodology for developing estimates of compliance costs in this study is the same as in our July 2014 report, although of course the numerical values are different reflecting the additional information now available. As noted, EPA developed updated estimates of the annualized costs from "known" controls, and we used this updated information on "known" controls.

As in the July 2014 analysis, emission reductions from "known" controls were not sufficient to achieve attainment, in this case with a 65 ppb ozone standard. EPA has filled the gap with a rough estimate of costs of "unknown" controls, *i.e.*, controls for which no cost information was developed. In contrast to the two cost estimation methodologies presented in its 2008 and 2010 RIAs, this time EPA used a single simplistic assumption that annualized control costs for these "unknown" controls would be equal to $15,000 per ton, regardless of the state, the sector, or the amount of emission reduction required. This estimate was not based upon any evidence-based analyses of the nature of the emissions that remain after "known" controls are in place, or of the costs of potential additional controls for these sources.

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[3] We focused our analysis on NO_X emissions, but we also included EPA's estimates of VOC emission control costs in our modeling.

Our compliance cost estimates are based upon a synthesis of EPA estimates of emission reduction, our modifications of EPA's assumptions regarding baseline reductions, EPA's estimates of the costs of "known" controls, and our more detailed estimates of the costs of "unknown" controls. As in our July 2014 report, our "unknown" cost estimates are more evidence-based than EPA's, as we use detailed information on the types of sources that account for the remaining emissions (EGUs, other point sources, on-road sources, off-road mobile sources, and area sources) as well as estimates of the potential costs of reducing emissions by scrapping existing emission sources prematurely. We updated our estimates of the costs of scrapping light-duty motor vehicles using up-to-date information. We also used updated information to assess the implications of these dollar-per-ton values for the marginal cost curve for reductions needed to achieve compliance. As in the July 2014 study, the result is a set of estimates of the costs for each state to comply with a more stringent ozone standard based upon the use of specific information to assess "unknown" control costs.

Methodology for Estimating Economic Impacts

Our methodology for estimating economic impacts of the estimated costs of compliance with a 65 ppb ozone standard is the same as in the July 2014 study for a 60 ppb standard, using NERA's $\mathrm{N_{ew}ERA}$ macroeconomic model. In the $\mathrm{N_{ew}ERA}$ model, expenditures on emissions control measures to comply with a new ozone standard reduce investment in other productive sectors of the economy, which results in decreases in economic output in subsequent years. The capital costs associated with compliance spending are assumed to be incurred from 2017 until 2036 (the last projected compliance date, for extreme areas), while each state's estimated operating and maintenance (O&M) costs are incurred for all years after the state's attainment date. Our economic impact analysis accounts for the effects of costs projected to be incurred through 2040.

$\mathrm{N_{ew}ERA}$ is an economy-wide integrated energy and economic model that includes a bottom-up, unit-specific representation of the electric sector, as well as a representation of all other sectors of the economy and households. It assesses, on an integrated basis, the effects of major policies on individual sectors as well as the overall economy. It has substantial detail for all of the energy sources used by the economy, with separate sectors for coal production, crude oil extraction, electricity generation, refined petroleum products, and natural gas production. The model performs its analysis with regional detail. As discussed above, this particular analysis uses state-specific cost inputs, and $\mathrm{N_{ew}ERA}$ has been run to assess economic impacts for each state. Appendix A of the July 2014 report provides a detailed description of the $\mathrm{N_{ew}ERA}$ model.

The macroeconomic analysis requires a baseline that projects economic outcomes in the absence of the incremental spending to attain the tighter ozone NAAQS. For this study, $\mathrm{N_{ew}ERA}$'s baseline conditions were calibrated to reflect projections developed by Federal government agencies, notably the Energy Information Administration (EIA) as defined in its *Annual Energy Outlook 2014* (*AEO 2014*) Reference case. This baseline includes the effects of environmental regulations that have already been promulgated as well as other factors that lead to changes over time in the U.S. economy and the various sectors. Our baseline does not include the effects of proposed regulations, such as the Clean Power Plan (CPP), although we do include power sector closures as an available way to attain the NAAQS, to the extent that we find such closures to be cost-effective elements of each state's control strategy.[4]

The July 2014 report and appendices provide details on the various aspects of our methodology, subject to the changes noted above. Although this Executive Summary report describes results for the United States as a whole and disaggregated to 11 regions,[5] the inputs and the results are built up using detailed state-specific and sector-specific cost information. The costs and impacts of a more stringent ozone standard differ substantially among states.

Summary of National Results

Emission Reductions Required to Achieve a 65 ppb Ozone Standard

As Figure S-1 illustrates, national NO_X emissions have already been reduced substantially, from about 25.2 million tons in 1990 to 12.9 million tons in 2013 (EPA 2014b). EPA currently projects that U.S. NO_X emissions will be further reduced by existing rules and regulations to 8.2 million tons by 2025 (supplemented with N_{ew}ERA's projected baseline EGU emissions, which does not include the proposed CPP). Those additional emissions reductions between 2013 and 2025 will involve costs beyond the compliance costs estimated in this study. Economic activity (as measured by real GDP) in 2025 is projected to be more than double the level in 1990 (CEA 2014, Table B-3 and OMB 2013, Table 2), suggesting that U.S. NO_X sources will have been controlled by more than 80% by 2025, without the additional controls needed to attain a tighter ozone NAAQS.

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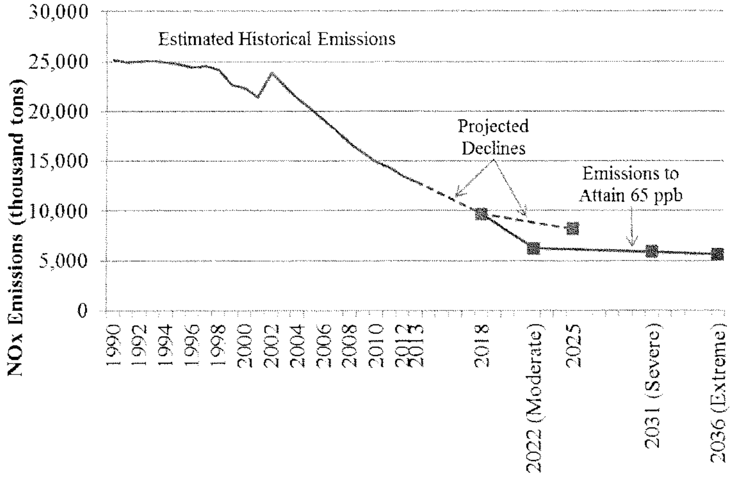
[4] EPA's inclusion of the CPP in its baseline was inconsistent with its standard practice of only including promulgated regulations. This deviation from standard procedure seems particularly unjustified given the enormous uncertainty in what carbon limits may actually be applied and how states would comply, and hence what NO_X emission reductions might actually occur as a result of this carbon regulation.

[5] "U.S." results are, formally, only for the lower 48 states, and exclude Alaska and Hawaii, as well as Washington DC. We refer to the lower 48 states as "U.S." hereafter.

Figure S-1: U.S. NO_X Emissions to Attain 65 ppb NAAQS Compared to Historical NO_X



Notes: Blue solid line: Estimated historical emissions.
Blue dotted line: Projected further declines through 2018 and 2025 (linear interpolation).
Red line: Emissions to attain 65 ppb on attainment schedule, with states not requiring reductions for 65 ppb held constant after 2025.
The slight increase in U.S. NO_X emissions from 2001 to 2002 primarily reflects changes in EPA's emission modeling methodology for onroad and nonroad sources (switching from MOBILE6 to the National Mobile Inventory Model and MOVES)

Source: NERA calculations as explained in text

Based on the EPA information, total U.S. NO_X emissions would have to be reduced to about 6.2 million tons by 2022 and 5.6 million tons by 2036 to meet a 65 ppb standard throughout the nation. This reduction appears as the red line above in Figure S-1, which also shows our prognosis of the timing of those reductions, based on our estimates of the likely severity classifications of the different states.[6]

Figure S-2 shows our estimates of emissions and emission reductions for the 34 states that would not attain a 65 ppb under baseline conditions. Despite the extensive controls already expected to occur in the future, we estimate that about 2.6 million additional tons (in aggregate) would need to be eliminated by 2022 and an additional 300,000 tons would need to be eliminated by 2036 in order for those states to come into attainment on schedule. This is equivalent to roughly another 25% reduction from the reduction estimated solely based on those states' 2025 NO_X emissions. It implies almost a 90% total reduction from all sizes and types of NO_X-emitting sources from the relatively uncontrolled emissions rates in 1990 (after adjusting for growth).

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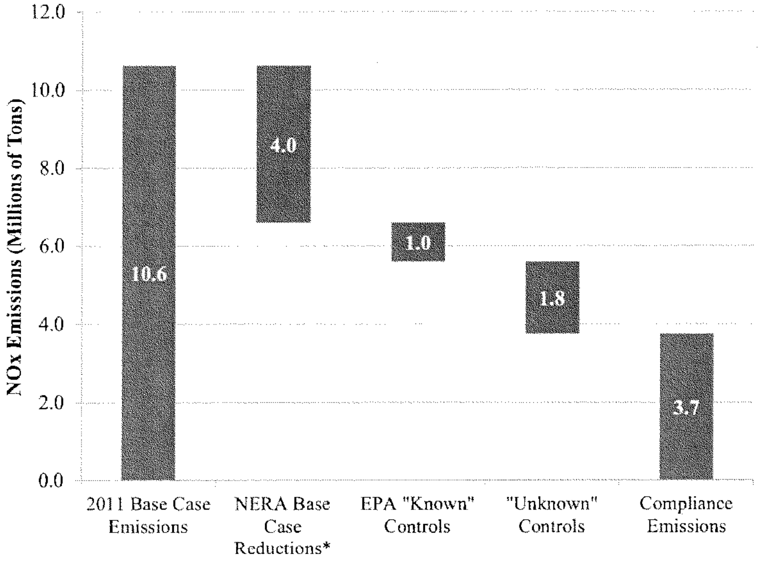
[6] Nonattainment areas are given different classifications—marginal, moderate, serious, severe or extreme—depending on how far out of attainment they are with the NAAQS at the time that designations must be made, two years after promulgation.

Figure S-2: NO_X Emissions and Categories of NO_X Reductions to Attain 65 ppb NAAQS (for 34 Non-Attaining States Only)



Note: Emissions and reductions include only states requiring emission reductions for compliance with a new ozone NAAQS of 65 ppb in this analysis.
*The NERA Base Case reflects 2022 conditions in each state requiring reductions, with two exceptions: The Base Case for UT and CA reflect conditions in 2031 and 2036, respectively, based on higher likely severity classifications in those two states.
Source: NERA calculations as explained in text

Figure S-3 shows the mix of emission reductions needed across 34 states that EPA projects will face compliance costs to achieve a 65 ppb ozone standard, including our estimates of the allocation of "unknown controls" to individual source categories. The dark green shows EPA's "known controls" and the light green shows NERA's evidence-based assumptions regarding where "unknown controls" will likely come from.[7] The remaining sum (shown in the blue bars) is 3.7 million tons—the aggregate limit for those 34 states to achieve attainment in all the states projected to be in nonattainment under baseline conditions. This 3.7 million ton aggregate limit needs to be met by the attainment deadlines, which we assume to be 2022 for all states except California and Utah, which are assumed to have much later attainment dates.[8]

As noted above, NERA's estimates of what the "unknown" controls will comprise includes deep cuts in the EGU sector, where emissions are concentrated in a few sources and costs per ton are thus lower than for the many smaller sources among the non-point source categories (*i.e.*, area, onroad mobile and nonroad mobile). NERA estimates that the remaining "unknown" controls outside of the EGU sector will involve much smaller incremental percentage reductions than from EGUs, because these will require programs such as scrapping a portion of vehicles and other small sources. These controls are also projected to come at a substantially higher cost per ton than the EGU controls—even though we assume that the small-source scrapping programs will only target the oldest, highest-emitting of each type of NO_X-emitting equipment.[9]

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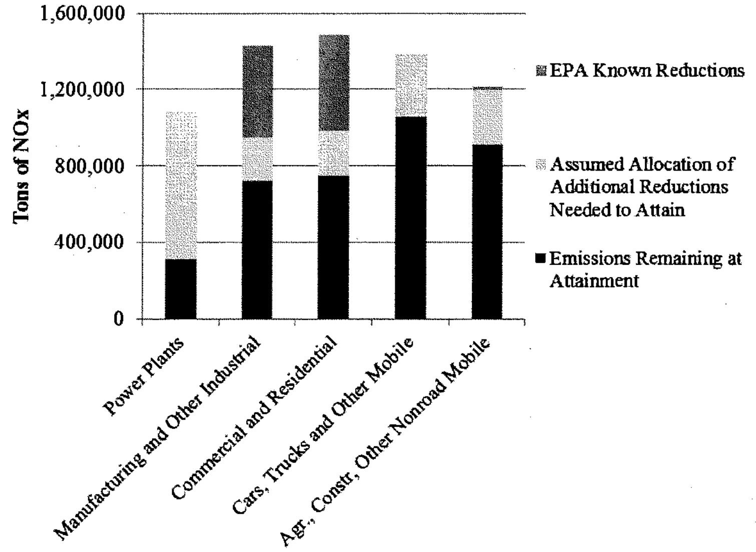
[7] This figure does not show the amount of EGU controls (mostly from installation of SCRs) that EPA has identified as "known" control in that sector because our analysis shows that one of the most cost-effective forms of control that EPA has called "unknown" will be to close those EGUs instead. Thus, we assume that the SCRs in EPA's list of "known" controls will not actually be installed, and replace their reductions with the much larger reductions that would come from EGU closures that are cost-effective for meeting a 65 ppb NAAQS (which appear as the light green area on the EGU bar).

[8] States that will be classified as marginal nonattainment in 2017 will face a 2020 attainment date, or will be re-designated as moderate, and then must be in attainment by 2023. Our analysis suggests that some of the marginal states may reach attainment by 2020 without incremental controls other than the baseline reductions, and they face no compliance cost in our analysis. We have assumed that marginal states that would not attain by 2020 under their baseline forecast will not undertake early costly action to avoid reclassification as moderate, and will attain by the moderate attainment date along with states that will have been classified as moderate in 2017.

[9] For example, our estimates of costs and tons removed by scrappage of light-duty cars is limited to vehicles still on the road in 2022 that are of a pre-2008 model year (*i.e.*, pre-Tier 2 vehicles). We estimate that those older vintages of cars will account for about 40% of projected light-duty vehicle emissions in 2022.

Figure S-3: NERA Analysis's Allocation of Additional Reductions Necessary to Attain a 65 ppb NAAQS to Categories of Emissions Sources in the 34 Non-Attaining States



Source: NERA calculations as explained in text

Compliance Costs to Achieve a 65 ppb Ozone Standard

We estimate that the potential costs of achieving a 65 ppb ozone standard could have a present value of almost $1.1 trillion as of 2014 (based upon costs incurred from 2017 through 2040), not including any costs for forcing a massive cutback in generation from coal-fired EGUs to reduce NO_X emissions from the power sector (whose costs are endogenously determined in the economic impact model).[10] These costs are reported in Figure S-4. As a rough point of comparison, we estimate that EPA's annualized cost estimate implies a present value of about \$167 billion.[11] The primary difference in our methodologies is the extrapolation method used to estimate the cost of "unknown" controls; we attempted to assess the kinds of controls that would be required after "known" controls and based our method on the estimated costs per ton of one such control (vehicle scrappage), whereas EPA relied on an arbitrary constant value.

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[10] Although the precise costs of the EGU closures is determined in the model, we used preliminary model runs to identify which closures would be as or more cost-effective than other unknown controls in our analysis. Based on this exercise, we estimate that the majority of the NO_X emission reductions associated with the EGU closures cost an average of about $16,000 per ton, and range well above $30,000 per ton in some states. The result of the constraints that we applied was 34 GW of outright unit retirements, but a substantial number of additional GW of coal-fired capacity is left on-line but no longer generates in the model. This means that more than 34 GW is effectively closed down in our analysis.

Figure S-4: Potential U.S. Compliance Spending Costs for 65 ppb Ozone Standard

	Present Value (Billions of 2014$)			Cumulative
	Capital	O&M	Total	Coal Retirements
Compliance Costs	$430	$630	$1,050	34 GW

Notes: Total is not equal to the sum of capital and O&M due to independent rounding. Present value is from 2017 through 2040, discounted to 2014 at a 5% real discount rate.
Cumulative coal retirements are incremental to baseline. These retirements are primarily due to assumed emission control measures but may also include indirect electric sector impacts of the ozone standards. This number is understated because it reflects only those plants that the model literally closes, while substantial additional GW of coal unit capacity is not reported by the model as "retired" but nevertheless is forced into a position of near-zero utilization.

Source: NERA calculations as explained in text

Allocating the estimated capital costs to spending in years prior to each state's projected compliance deadline, and allocating O&M costs to years after the respective compliance deadlines, Figure S-5 shows the pattern of annual compliance spending across all states (except for the endogenously-determined costs of coal unit retirements.)

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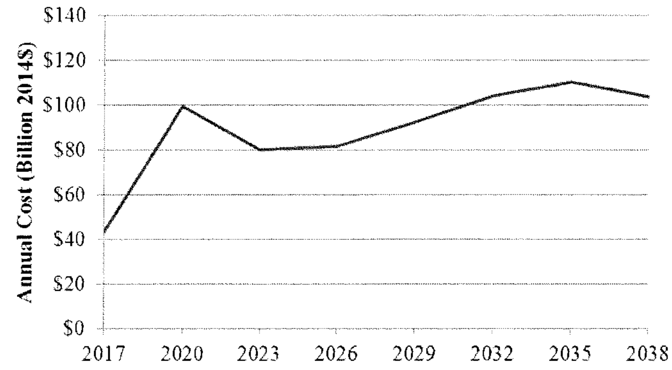
[11] This estimate assumes that EPA's total annualized cost estimate of \$17 billion (including California) is incurred over a period of 20 years; that these 20 years begin in 2020, except in California where they begin in 2030; that these annual costs are converted to a present value in 2014 using a real annual discount rate of 5%; and that the present value is converted from 2011 dollars to 2014 dollars. Note that there are many differences in the EPA and NERA calculations so this estimate can only be viewed as providing a rough comparison.

Figure S-5: Potential Annual U.S. Compliance Spending Costs for 65 ppb Ozone Standard



Notes: Figure does not include compliance costs associated control measures in the electric power sector (scrappage of coal-fired power plants), which are modeled in N_{ew}ERA.
Source: NERA calculations as explained in text

Potential Impacts on the U.S. Economy and U.S. Households

The potential costs we estimated for a 65 ppb ozone standard are projected to have substantial impacts on the U.S. economy and U.S. households. Figure S-6 shows the potential macroeconomic effects as measured by GDP and U.S. household consumption. The 65 ppb ozone standard is projected to reduce GDP from the baseline levels by about $1.7 trillion on a present value basis from 2017 to 2040 (as of 2014, and in 2014 dollars) and by $140 billion per year on a levelized average basis over that period (*i.e.*, when spread evenly over years but retaining the same present value). Average annual household consumption over those same years could be reduced by an average of about $830 per household per year.

Figure S-6: Potential Impacts of 65 ppb Ozone Standard on U.S. Gross Domestic Product and Household Consumption

	Annualized	**Present Value**
GDP Loss (Billions of 2014$)	$140/year	$1,720
Consumption Loss per Household (2014$)	$830/year	N/A

Notes: Present value is from 2017 through 2040, discounted at a 5% real discount rate. Consumption per household is an annualized (or levelized) value calculated using a 5% real discount rate.
Source: NERA calculations as explained in text

Figure S-7 focuses on several dimensions of projected impacts on income from labor ("worker income") as a result of the 65 ppb ozone standard. Relative to baseline levels, real wages decline by about 0.6% on average over the period and labor income declines by about 0.9% on average, resulting in job-equivalent losses that average about 1.4 million job-equivalents. (Job-equivalents are defined as the change in labor income divided by the annual baseline income for the average job (see Figure S-7)). A loss of one job-equivalent does not necessarily mean one less employed person—it may be manifested as a combination of fewer people working and less income per worker. However, this measure allows us to express employment-related impacts in terms of an equivalent number of employees earning the average prevailing wage.[12] These are the *net* effects on labor and include the positive benefits of increased labor demand in sectors providing pollution control equipment and technologies.

Figure S-7: Potential Impacts of 65 ppb Ozone Standard on Labor

	Avg.
Baseline Annual Job-Equivalents (millions)	156
65 ppb Case:	
Real Wage Rate (% Change from Baseline)	-0.6%
Change in Labor Income (% Change from Baseline)	-0.9%
Job-Equivalents (Change from Baseline, millions)	-1.4

Notes: Average (Avg.) is the simple average over 2017-2040. "Job-equivalents" is defined as total labor income change divided by the average annual income per job. This measure does not represent a projection of numbers of workers that may need to change jobs and/or be unemployed, as some or all of the loss could be spread across workers who remain employed

Source: NERA calculations as explained in text

Potential Effects on U.S. Energy Prices

Emissions reduction costs of a 65 ppb ozone standard also is likely to have impacts on U.S. energy sectors, largely because the more stringent ozone standard is projected to lead to the premature retirement of many additional coal-fired power plants. Figure S-8 shows average energy price projections under the baseline and the 65 ppb ozone standard. The average delivered residential electricity price is projected to increase by an average of 1.7% over the period from 2017 through 2040 relative to what they could otherwise be in each year (which is projected to be rising even without a tighter ozone NAAQS). Henry Hub natural gas prices are projected to increase by an average of 3.7% in the same time period (again, relative to what they could otherwise be in each future year), while delivered residential natural gas prices could increase by an average of 3.7%. Part of the increase in delivered natural gas prices reflects the increase in pipeline costs due to control costs for reductions in NO_X emissions in the pipeline system that could be recovered through tariff rates.

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[12] The N$_{ew}$ERA model, like many other similar economic models, does not develop projections of unemployment rates or layoffs associated with reductions in labor income. Modeling such largely transitional phenomena requires a different type of modeling methodology; our methodology considers only the long-run, equilibrium impact levels.

Figure S-8: Potential Impacts of a 65 ppb Ozone Standard on Energy Prices Relative to Their Projected Levels in Each Future Year

		Avg. Baseline	**Avg. 65 ppb Case**	**Change**	**% Change**
Henry Hub Natural Gas	$/MMBtu	$6.22	$6.47	$0.25	3.7%
Natural Gas Delivered (Residential)	$/MMBtu	$14.23	$14.76	$0.53	3.7%
Natural Gas Delivered (Industrial)	$/MMBtu	$8.71	$9.27	$0.55	6.3%
Gasoline	$/gallon	$3.68	$3.69	$0.01	0.3%
Electricity (Residential)	¢/kWh	14.9¢	15.2¢	0.2¢	1.7%
Electricity (Industrial)	¢/kWh	9.7¢	10.0¢	0.3¢	2.8%

Notes: Average is the simple average over 2017-2040. The Baseline reflects expected growth in prices over the analysis period as predicted by the *Annual Energy Outlook 2014*. Figures in 2014$.

Source: NERA calculations as explained in text

Potential Effects on U.S. Sectors and Regions

All sectors of the economy would be affected by a 65 ppb ozone standard, both directly through increased emissions control costs and indirectly through impacts on affected entities' customers and/or suppliers. There are noticeable differences across sectors, however. Figure S-9 and Figure S-10 show the estimated changes in output for the non-energy and energy sectors of the economy, respectively, due to the emissions reduction costs of a 65 ppb ozone standard.

Figure S-9: Potential Impacts of 65 ppb Ozone Standard on Output of Non-Energy Sectors (Percentage Changes from Baseline)

	Agriculture	Commercial/ Services	Manufacturing	Commercial Transportation	Commercial Trucking
Average (2017-2040)	-0.9%	-0.4%	-0.3%	-0.9%	-0.5%

Note: Values are the simple average of percentage change over 2017-2040.
Source: NERA calculations as explained in text

Figure S-10: Potential Impacts of a 65 ppb Ozone Standard on Output of Energy Sectors (Percentage Changes from Baseline)

	Coal	Natural Gas	Crude Oil/Refining	Electricity
Average (2017-2040)	-28%	3.9%	-0.8%	-1.5%

Note: Values are the simple average of percentage change over 2017-2040.
Source: NERA calculations as explained in text

Figure S-11 shows the estimated average annual change in consumption per household for individual N_{ew}ERA regions. A region's attainment costs and its sectoral output mix determine to a large extent whether a region fares better or worse than the U.S. average, but all regions could experience lower household consumption.

Figure S-11: Potential Impacts of a 65 ppb Ozone Standard on Annual Consumption per Household by Region

Region	2014$
Arizona and Mountain States	-$690
California	-$790
Florida	-$250
Mid-America	-$770
Mid-Atlantic	-$1,370
Mississippi Valley	-$640
New York/New England	-$1,530
Pacific Northwest	-$310
Southeast	-$620
Texas, Oklahoma, Louisiana	-$1,290
Upper Midwest	-$490
U.S.	**-$830**

Notes: Values are the levelized average over 2017-2040, annualized using a 5% real discount rate.
Maps of N_{ew}ERA regions are provided in the report body and Appendix A.

Source: NERA calculations as explained in text

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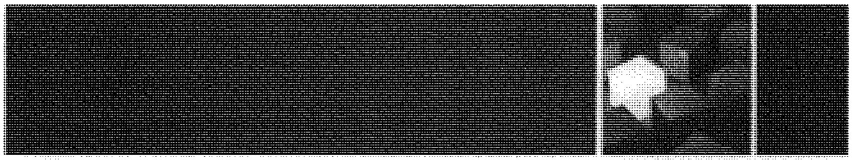

NERA
ECONOMIC CONSULTING

200 Clarendon Street
11th Floor
Boston, MA 02116
617-927-4500

1255 23rd St, NW
Suite 600
Washington, D.C. 20037
202-466-3510

www.nera.com

American Chemistry Council

Statement of the American Chemistry Council on EPA's Proposed Ozone NAAQS
House Committee on Science, Space and Technology Hearing
"Reality Check: The Impact and Achievability of EPA's Proposed Ozone Standards"
March 17, 2015

Thank you, Chairman Smith, for holding such a critical hearing today, focusing on the impact and achievability of EPA's proposed ozone standards. The American Chemistry Council (ACC) is pleased to offer this statement at the hearing. ACC[1] represents the leading companies engaged in the business of chemistry. We apply the science of chemistry to create innovative products and services that make people's lives better, healthier, and safer. The U.S. chemical industry is a key element of the economy, providing 793,000 skilled, good-paying jobs across the country. We are among the nation's largest exporters and investors in research and development. Our advanced materials and technologies include many that help save energy and reduce greenhouse gas emissions.

ACC is opposed to EPA's proposal to lower the ozone National Ambient Air Quality Standard (NAAQS).

EPA Administrator Has Discretion to Set the Standard

In setting the 2008 ozone standard, EPA Administrator Stephen Johnson said CASAC's recommendation appeared to be based on "a mixture of scientific and policy considerations," noting that he was "in general agreement with CASAC's views concerning the interpretation of the scientific evidence. The Administrator also note[d] that *there is no bright line clearly directing the choice of level and the choice of what is appropriate is clearly a public health policy judgment entrusted to the Administrator*."[2] Given the discretion afforded him under the Clean Air Act, Administrator Johnson set the standard at 0.075 ppm.

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[1] ACC members apply the science of chemistry to make innovative products and services that make people's lives better, healthier and safer. ACC is committed to improved environmental, health and safety performance through Responsible Care®, common sense advocacy designed to address major public policy issues, and health and environmental research and product testing. The business of chemistry is an $812 billion enterprise and a key element of the nation's economy. It is the nation's largest exporter, accounting for twelve percent of all U.S. exports. Chemistry companies are among the largest investors in research and development. Safety and security have always been primary concerns of ACC members, and they have intensified their efforts, working closely with government agencies to improve security and to defend against any threat to the nation's critical infrastructure.

[2] pp. 16482-83, *Federal Register Volume 73, Number 60, March 27, 2008, National Ambient Air Quality Standards for Ozone, Final Rule*, emphasis added

The Health Science Evidence Does Not Support Lowering the Standard

ACC believes in appropriately peer-reviewed sound science. We do not believe the scientific evidence supports a lowering of the standard. EPA's existing ozone standard of 0.075 ppm, through a series of significant emission control programs, will continue to provide ample protection of public health. Moreover, there are numerous questions about the science being used to justify a lower standard: Some recent health studies contain inconsistent or conflicting findings, while others are re-analyses of previous studies that rely on outdated information.

U.S. Air Quality Continues to Improve

The nation's air quality has significantly improved and continues to improve with new voluntary and regulatory programs already in place or being implemented. According to EPA, total emissions of the six principal criteria air pollutants fell by 62 percent between 1980 and 2013.

Voluntary and regulatory emission reduction programs will continue to yield benefits for decades to come. Over the next twenty years, cleaner fuel rules and utility regulations are expected to produce large air quality improvements. Current emission reduction programs will continue to reduce ozone concentrations through 2030.

ACC Member Company Contributions to Cleaner Air

ACC members understand and value the importance of clean air, and we support protecting public health and the environment. Our commitment is reflected in our significant and continued progress in reducing emissions. Since 1990, ACC member companies and the broader business of chemistry have reduced nitrogen oxides by 70%, sulfur dioxide by 58%, volatile organic compounds by 87% and fine particulate emissions by 65%. These results are due to a combination of voluntary member company initiatives, such as Responsible Care®, and regulatory programs.

ACC member companies make a wide range of solutions, such as plastics and insulation products, which help save energy in vehicles, homes, and businesses. The energy savings result in lower emissions of greenhouse gases and ozone precursors such as NO_x.

A Lower Standard Could Stall Manufacturing Growth

The shale gas revolution is driving a historic expansion in American chemistry. More than $137 billion in new chemical industry investment is planned or underway, thanks to plentiful and affordable supplies of natural gas and natural gas liquids. Fully 60 percent is foreign direct investment. The 225 projects – new plants, expansions, and factory restarts – could create and support nearly 700,000 jobs by 2023. They will also generate increased GDP, tax revenue, and access to innovative new products.

A lower ozone standard could impede manufacturing growth in many areas of the country. On November 26, 2014, EPA proposed a more stringent standard of between 0.065 and 0.070 ppm. Much of the U.S. will be unable to meet a lower NAAQS. Manufacturing growth could slow or stop in states that find themselves in non-compliance, since facilities located in "nonattainment" areas face burdensome and extensive regulatory requirements. These rules make investment projects far more costly and complex.

To safeguard the significant planned investment in chemical manufacturing in the United States, and to ensure that the industry can create the jobs and products that foster economic growth, we need regulatory policies that do not impose unnecessary barriers to growth in our sector. EPA's anticipated proposal to lower the ozone NAAQS will impose significant burdens and hurdles on new investment.

Communities and Industry in "Nonattainment" Areas Face Significant Challenges

Currently, 222 counties covering a population of over 120 million people are classified in nonattainment with the 0.075 ppm standard. If EPA revises the standard to the lower end of the proposed range, we estimate that more than 2000 counties – urban and rural – would be in nonattainment, based on the 2011-2013 design values and modeling.

Communities designated "nonattainment" have a hard time attracting and retaining industry and sustaining economic activity and growth. Industry located in a nonattainment area face increased operating costs, permitting delays, and restrictions on building or expanding facilities. These challenges increase the "time to market" for innovative new products.

New facilities and expansions in nonattainment areas cannot proceed until emissions are offset. Offsets are not always readily available, and increase in price as they become scarce. For example, offset prices in the Houston-Galveston-Brazoria nonattainment area are more than \$200,000/ton for NOx and \$300,000/ton for VOC. Offset prices in southern California nonattainment areas are approaching \$125,000/ton of NOx.

Even facilities that are not expanding can experience the burdens of operating in a nonattainment area. For example, in the Houston area, which is in nonattainment with the current standard, existing facilities are subject to additional controls under the Highly Reactive VOC (HRVOC) rule. Combustion units, such as boilers and ethylene crackers, must install costly SCRs and low-NOx burners. They may also lose federal highway and transit funding, as federal projects must conform with State Implementation Plans (SIPs) in order to proceed. Furthermore, facilities located in counties designated as in "severe" or "extreme" nonattainment will face significant Section 185 fees for emissions in their area, even though many of these facilities have already spent many millions of dollars to reduce emissions.

A Better Path Forward

The current ozone standard of 0.075 ppm is the most stringent ever and has not been fully implemented across the United States. EPA and states should focus on fully implementing and attaining the existing standard before contemplating a lower standard – an approach that will continue to provide necessary health protection. As the science develops further, EPA will have the opportunity to determine whether any additional actions might be warranted in the future.

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March 16, 2015

The Honorable Gina McCarthy
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Dear Administrator McCarthy,

In the four decades since the Clean Air Act was signed into law, our states have driven unprecedented improvements in air quality. We have done so while adhering to the core principle that meaningful environmental measures can and must coexist with free market policies that promote job growth and economic freedom. Your agency's new proposed change to the National Ambient Air Quality Standard (NAAQS) for ground-level ozone jettisons these free market policies in favor of an onerous, job-crushing standard. As chief protectors of our states' economies, we oppose this proposed change to the NAAQS for ground-level ozone.

The proposed NAAQS is so extreme that even some of our pristine national parks may not be able to satisfy it. It goes without saying that most cities and counties have no chance of attaining this standard. Indeed, many areas of our states have background levels of ozone at or near the levels you are proposing. According to an estimate by the Congressional Research Service, EPA's power-grab could plunge anywhere from 76% to 96% of the counties currently monitored for ozone into nonattainment.

Nonattainment is an economic penalty box so severe that needed economic growth is stunted. In nonattainment areas, any growth is predicated on successfully navigating a bureaucratic maze of federal and state regulators. New development resulting in any new ozone emissions in the area must be offset with emission reductions elsewhere—turning economic development into a zero-sum game. Some businesses will be forced to employ costly control measures. Some will likely scrap existing facilities and equipment altogether. The end result, of course, is that the costs will be passed on to hard-working Americans. Millions of Americans could be affected in a much more direct and devastating way: it is estimated that the proposed standard could cost the equivalent of 1.4 million jobs annually.

Nonattainment also jeopardizes needed transportation infrastructure projects. Roads that would add desperately needed capacity in nonattainment areas would be subject to review by multiple federal agencies—despite the fact that many of these projects may actually reduce ozone emissions by relieving congestion. This additional level of oversight is sure to both delay needed transportation projects and make them more expensive—if not thwart them altogether. It's no wonder many are calling this "the most expensive regulation ever."

All of this says nothing of the dozens of massive new regulations put in place or proposed by your agency over the past several years: regulations like the Mercury and Air Toxics Standards, the Boiler MACT, fuel economy standards for cars and trucks, regional haze rules, the Cross-State Air Pollution Rule, Tier 3 tailpipe emissions standards, and of course the Clean Power Plan. Taken together, these regulations impose billions of dollars in new costs on our states and our citizens. Moreover, these regulations collectively work to lower ozone emissions already. Piling on the additional burden and expense of a lower ozone standard simply isn't necessary. In fact, many of our states have seen a dramatic decrease in ozone levels over the past decade under the current, more flexible standard.

Our states' resources are not infinite. At a time when we should be focusing on growing the economy and creating jobs, the EPA is imposing a steady stream of complex, expensive new regulations that require an army of policy and technical experts and lawyers to decipher, respond to, and ultimately implement. The proposed NAAQS for ozone is the most onerous and expensive yet. We ask you to instead keep the current standard of 75 parts per billion (ppb) in place.

Sincerely,

Nathan Deal

Governor Asa Hutchinson
Arkansas

Governor Nathan Deal
Georgia

Governor C.L. "Butch" Otter
Idaho

Michael R. Pence

Governor Michael R. Pence
Indiana

Governor Bobby Jindal
Louisiana

Paul R LePage

Governor Paul R. LePage
Maine

Phil Bryant

Governor Phil Bryant
Mississippi

Mary Fallin

Governor Mary Fallin
Oklahoma

Nikki R. Haley

Governor Nikki Haley
South Carolina

Greg Abbott

Governor Greg Abbott
Texas

Governor Scott Walker
Wisconsin

Neighborhood poverty, urban residence, race/ethnicity, and asthma: Rethinking the inner-city asthma epidemic

Corinne A. Keet, MD, PhD,[a] Meredith C. McCormack, MD,[b] Craig E. Pollack, MD, MHS,[c] Roger D. Peng, PhD,[d] Emily McGowan, MD,[e,f] and Elizabeth C. Matsui, MD, MHS[a] *Baltimore, Md*

Background: Although it is thought that inner-city areas have a high burden of asthma, the prevalence of asthma in inner cities across the United States is not known.
Objective: We sought to estimate the prevalence of current asthma in US children living in inner-city and non–inner-city areas and to examine whether urban residence, poverty, or race/ethnicity are the main drivers of asthma disparities.
Methods: The National Health Interview Survey 2009-2011 was linked by census tract to data from the US Census and the National Center for Health Statistics. Multivariate logistic regression models adjusted for sex; age; race/ethnicity; residence in an urban, suburban, medium metro, or small metro/rural area; poverty; and birth outside the United States, with current asthma and asthma morbidity as outcome variables. Inner-city areas were defined as urban areas with 20% or more of households at below the poverty line.
Results: We included 23,065 children living in 5,853 census tracts. The prevalence of current asthma was 12.9% in inner-city and 10.6% in non–inner-city areas, but this difference was not significant after adjusting for race/ethnicity, region, age, and sex. In fully adjusted models black race, Puerto Rican ethnicity, and lower household income but not residence in poor or urban areas were independent risk factors for current asthma. Household poverty increased the risk of asthma among non-Hispanics and Puerto Ricans but not among other Hispanics. Associations with asthma morbidity were very similar to those with prevalent asthma.
Conclusions: Although the prevalence of asthma is high in some inner-city areas, this is largely explained by demographic factors and not by living in an urban neighborhood. (J Allergy Clin Immunol 2014;■■■:■■■-■■■.)

Key words: *Inner-city asthma, childhood asthma, urban/rural, neighborhood, race/ethnicity*

The idea that certain features of life in poor urban areas promote asthma dates back to more than a half century ago, when researchers began to describe an "inner-city asthma epidemic" of high asthma prevalence and morbidity in poor areas of large cities.[1-8] Research focusing on the inner city, which was typically defined as census tracts in large metro center areas with at least 20% of households at below the poverty line,[9] has led to significant advances in our understanding of what causes asthma and how to treat it,[10] but the prevalence of asthma in inner-city areas across the United States is not known nor is it known how it compares with prevalence in other types of communities. Studies of asthma prevalence in the inner city have generally focused on individual urban communities and have not separated demographic features of inner-city areas from their metropolitan status.[5,11-19] Nationally representative studies have also had several limitations, including the fact that much of the work on the relative contribution of metropolitan status to asthma disparities overall was done decades ago, used measures of metropolitan status that are not consistent with National Institutes of Health definitions of the inner city, and rarely looked at the independent contributions of poverty, metropolitan status, and race/ethnicity.[3,6,20] Despite our significant and ongoing national commitment to combating inner-city asthma, we do not actually know the prevalence of asthma in inner cities across the United States, whether it is in fact greater than that found in other areas, and, if there are differences, whether race/ethnicity, poverty, or residence in an urban area explain them.

Thus our primary objectives were to (1) estimate childhood asthma prevalence for inner-city and non–inner-city areas in the United States and (2) disentangle the effects of urban residence, neighborhood-level poverty, race/ethnicity, and household poverty on asthma prevalence. Understanding whether asthma disparities seen in various geographic areas are primarily a result of environmental exposures concentrated in the inner city or are instead related to sociodemographic features of the inhabitants of these neighborhoods is key to advancing an efficient and effective national research and public health agenda.

METHODS

Data were drawn from the National Health Interview Survey (NHIS) 2009-2011. The NHIS is a survey conducted annually by the National Center for

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From the Divisions of [a]Pediatric Allergy and Immunology, [b]Pulmonary and Critical Care Medicine, [c]General Internal Medicine, and [e]Allergy and Clinical Immunology, Johns Hopkins University School of Medicine, and [d]the Department of Biostatistics and [f]the Graduate Program in Clinical Investigation, Johns Hopkins Bloomberg School of Public Health, Baltimore.

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Corresponding author: Corinne A. Keet, MD, PhD, The Johns Hopkins Hospital, CMSC 1102, 600 N Wolfe St, Baltimore, MD 21287. E-mail: ckeet1@jhmi.edu.

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Abbreviations used
CDC: Centers for Disease Control and Prevention
NCHS: National Center for Health Statistics
NHIS: National Health Interview Survey
OR: Odds ratio

Health Statistics (NCHS), which is part of the Centers for Disease Control and Prevention (CDC). It has a multistate probability design that covers all 50 states and the District of Columbia and is intended to be representative of the civilian noninstitutionalized population living in the United States. Black, Asian, and Hispanic populations are oversampled to increase precision of estimates in certain subgroups. Data collection is done in person using a computer-assisted personal interviewing mode. The overall response rate for the child section of these surveys ranged from 71% to 75%.[21-23] Because asthma is not reliably diagnosed in young children, the sample population was limited to children aged 6 to 17 years.

To evaluate the effect of geographic variables on asthma outcomes, we linked participants' census tracts, as classified by the 2000 Census, to 2 additional data sets: the 2006 NCHS Urban-Rural Classification Scheme for Counties and the 2000 US Census. The 2006 NCHS Urban-Rural Classification scheme divides counties into 6 categories based on population density and other measures of urbanization: (1) large metro, central; (2) large metro, fringe; (3) medium metro; (4) small metro; (5) micropolitan; and (6) noncore. Generally, "large metro, central" is considered the urban core, whereas "large metro, fringe" is thought to be equivalent to "suburban."[24] Because there were relatively few people residing in small metro, micropolitan, and noncore areas, these categories were combined and classified as small metro/rural areas. The 2000 Census provided the percentage of households living at below the federally defined poverty level in each census tract. This was generally treated as a continuous variable in our analyses, although in some analyses we defined inner-city neighborhoods as census tracts located in large metro central areas with 20% or more of households at below the poverty line.[9] *Household income* was defined as household income divided by the federally defined poverty level.

Ever asthma was defined by a yes answer to the following question: "Has a doctor or other health professional EVER told you that [name] had asthma?" Other questions that defined asthma were as follows: "Does [name] still have asthma?," which was used for current asthma. "During the past 12 months, has [name] had an episode of asthma or an asthma attack?," which was used for an asthma episode. "During the past 12 months, did [name] have to visit an emergency room or urgent care center because of [his/her] asthma?," which was for an asthma emergency department visit.

Race/ethnicity was by self-report and recoded in the NHIS data in the following categories: Hispanic, non-Hispanic white (called "white" here), non-Hispanic black (called "black" here), non-Hispanic Asian (called "Asian" here), and all other race/ethnicities, a group comprising less than 1% of the total population. Because it has been previously reported that Puerto Rican Hispanics have different asthma risk than other Hispanics,[25] we created a separate race/ethnicity category for those of Puerto Rican heritage. Hereafter, "Hispanic" refers to non-Puerto Rican Hispanics.

Although multilevel modeling is often used in analyses of the association between neighborhood factors and disease, multilevel modeling typically requires at least 25 subjects per group (in this case census tract),[26] and in this analysis there were an average of only 4 subjects per census tract. Thus, for this analysis, standard survey methods were used with sample weights and strata provided in the survey. This accounts for the complex survey design, correctly adjusts the variances for clustering within a sampling unit, and does not require a minimum number of subjects per group. For analyses of individual-level income, the CDC provides multiply imputed data for subjects missing income data. These data are generated by the CDC by using sequential regression multivariate imputation implemented with the module IMPUTE with IVEware (www.isr.umich.edu/src/smp/ive)[27] and were analyzed with the MI ESTIMATE commands in Stata, which accounts for the imputation uncertainty using the methods of Rubin.[28] Three logistic regression models for prediction of current asthma; asthma episodes, and emergency department visits in the past year were generated: crude bivariate analyses; multivariate models adjusted for age, sex, race/ethnicity, region of residence, neighborhood-level poverty, and urban/rural status; and multivariate models additionally adjusted for household income. To determine whether race/ethnicity or metropolitan residence modified the relationship between poverty and asthma, we also investigated interactions between these factors and constructed stratified models. Model diagnostics included the Pearson goodness-of-fit test, visual examination of the data, and sensitivity analyses excluding very large values. Individual- and neighborhood-level poverty were examined for collinearity, and because the collinearity was not strong (variance inflation factor of 1.2), both variables were included in some models. Because we identified differences in the relationship between current asthma and both neighborhood- and individual-level poverty between Hispanics and non-Hispanics, we stratified these analyses into (1) Hispanics and (2) all others, including Puerto Ricans. Our analyses confirmed that children of Puerto Rican heritage were more similar to non-Hispanic populations than Hispanics in the relationship between asthma and poverty (data not shown), supporting this method of stratification. Sensitivity analyses of the main model were done, including the following variables: (1) whether the child had a well-child visit in the past year and (2) whether the child had at any point been uninsured in the past year. A significance level of .05 was used. All analyses were done with Stata 13/SE software (StataCorp, College Station, Tex). Because census tract information is not available in the public NHIS data set, these analyses were conducted at the Research Data Center with approval from the NCHS Research Ethics Review Board. Data collection for the NHIS was approved by the NCHS Research Ethics Review Board.

RESULTS

Population characteristics

Twenty-three thousand sixty-five subjects aged 6 to 17 years living in 5,853 different census tracts were included in this analysis. Because the sample was derived from a population-based survey and was weighted to reflect the noninstitutionalized US population, the demographics of the analytic population matched those of children aged 6 to 17 years in the United States as a whole (Table I). On average, subjects resided in census tracts in which 12% of households lived at below the poverty line. Twenty-eight percent resided in urban census tracts, 16% resided in poor tracts (defined as ≥20% living at below the poverty line), and 7% resided in poor urban tracts (the inner city, Table I). The lifetime asthma prevalence was 16.3%, the current asthma prevalence was 10.7%, 5.9% reported an asthma episode, and 1.6% reported visiting the emergency department for asthma in the prior year.

Prevalence of asthma in urban poor (inner-city) and other poor areas

The overall prevalence of current asthma in inner-city neighborhoods in the United States was 12.9% (95% CI, 11.1% to 14.9%) compared with 10.6% (95% CI, 10.0% to 11.2%) in non–inner-city areas ($P = .01$), but this difference was no longer significant after adjusting for race/ethnicity, region, sex, and age (odds ratio [OR], 1.01; 95% CI, 0.84-1.21; $P = .90$). Approximately 8% of asthmatic children are estimated to live in inner-city areas compared with 7% of children overall (see Table E1 in this article's Online Repository at www.jacionline.org). The prevalence of asthma in inner-city neighborhoods was not constant throughout the United States and ranged from 7.9% (95% CI, 5.9% to 10.5%) in the West to 17.3% (95% CI, 13.2% to 22.4%) in the Northeast (Fig 1). In addition, poor

TABLE I. Demographic characteristics

Characteristic	No.	Overall	Poor* urban (n = 2,411)	Nonpoor urban (n = 5,383)	Poor nonurban (n = 2,337)	Nonpoor nonurban (n = 12,934)
		% (95% CI)				
Race/ethnicity						
White	10,425	57.6 (56.5-58.7)	7.2 (5.0-10.3)	45.3 (42.3-47.8)	32.3 (28.3-36.6)	71.3 (70.0-72.6)
Black	4,067	15.2 (14.5-16.0)	36.7 (32.9-40.7)	16.7 (15.0-18.6)	28.5 (24.9-32.3)	10.4 (9.6-11.2)
Hispanic (non–Puerto Rican)	6,301	19.5 (18.7-20.4)	48 (44.2-52.0)	27 (25.0-29.2)	31 (27.3-35.1)	12.1 (11.1-13.2)
Puerto Rican	600	2.1 (1.8-2.3)	3.9 (2.9-5.2)	2.2 (1.7-2.8)	3.6 (2.6-4.9)	1.6 (1.3-1.9)
Asian	1,464	4.5 (4.1-4.9)	3.7 (2.6-5.3)	8.4 (7.4-9.6)	1.6 (1.1-2.4)	3.7 (3.3-4.2)
Region						
Northeast	3,475	16.5 (15.6-17.4)	24.2 (20.7-28.1)	11.2 (9.5-13.1)	9.5 (7.1-12.5)	18.5 (17.2-19.8)
Midwest	4,564	24.2 (23.0-25.3)	13.8 (11.2-16.7)	18.5 (15.8-21.5)	13.2 (9.7-17.6)	28.9 (27.2-30.5)
South	7,871	35.3 (34.0-36.6)	24.6 (20.7-29.0)	30.6 (27.6-33.7)	51.3 (46.1-56.5)	35.7 (34.0-37.5)
West	6,047	24.0 (22.8-25.2)	37.5 (32.7-42.5)	39.8 (36.8-42.8)	26.1 (22.0-30.7)	17.0 (15.4-18.7)
Born in United States						
Yes	21,320	94.3 (93.9-94.7)	89.1 (87.4-90.7)	92 (91.0-92.9)	92.9 (90.8-94.5)	95.9 (95.4-96.3)
No	1,735	5.7 (5.3-6.1)	10.9 (9.4-12.6)	8 (7.2-9.0)	7.1 (5.5-9.2)	4.1 (3.7-4.6)
Asthma prevalence						
Asthma, lifetime	3,933	16.3 (15.7-17.0)	18.7 (16.5-21.2)	15.3 (14.0-16.6)	19.2 (17.1-21.5)	16 (15.3-16.8)
Asthma, current	2,574	10.7 (10.2-11.3)	12.9 (11.1-14.9)	10 (9.0-11.2)	12.4 (10.8-14.2)	10.5 (9.9-11.2)
Asthma episode, past 12 mo	1,378	5.9 (5.5-6.3)	6.5 (5.5-7.7)	5.6 (4.8-6.5)	6.1 (4.9-7.6)	5.9 (5.4-6.4)
ED visit for asthma, past 12 mo	408	1.6 (1.4-1.8)	3.0 (2.2-4.0)	1.8 (1.3-2.5)	2.3 (1.6-3.1)	1.3 (1.4-1.8)

ED, Emergency department.

*Poor was defined as 20% or more of households living below the poverty line.

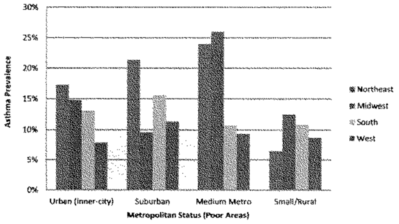

FIG 1. Asthma prevalence according to metropolitan status and region among children living in poor areas (defined as neighborhoods with ≥20% of households below the poverty line).

non–inner-city areas in some regions had prevalence rates exceeding those in inner-city areas (Fig 1 and see Table E2 in this article's Online Repository at www.jacionline.org). Although in crude stratified analyses inner-city areas in the Northeast had higher prevalence rates than non–inner-city areas, in stratified models adjusted for age, sex, place of birth, and race/ethnicity, the prevalence of asthma in inner-city neighborhoods was not significantly higher than in non–inner-city areas in any region of the United States (data not shown). As shown below, differences in asthma prevalence were driven by racial/ethnic and socioeconomic factors and not urban/rural status.

Associations with current asthma prevalence

Race/ethnicity. In unadjusted models current asthma prevalence was significantly higher among blacks (17.1%; 95% CI, 15.6% to 18.8%) and Puerto Ricans (19.8%; 95% CI, 16.6% to 23.5%) than among whites (9.6%; 95% CI, 8.9% to 10.3%), Hispanics (8.8%; 95% CI, 7.8% to 10.0%), and Asians (8.1%; 95% CI, 6.5% to 10.0%). Black race and Puerto Rican ethnicity remained strong and independent predictors of current asthma, even when neighborhood-level poverty, urban/rural status, region, sex, age, and birth in the United States were included in the model and, additionally, in analyses that further adjusted for household poverty (Table II and see Table E3 in this article's Online Repository at www.jacionline.org). Birth outside the United States was a strong and independent protective factor for asthma (Table II).

Neighborhood poverty. A 10 percentage point increase in the number of households living below the poverty line (neighborhood-level poverty) was associated with a 10% increase in the odds of prevalent asthma in crude analyses (OR, 1.10; 95% CI, 1.05-1.14; $P < .001$), although this was no longer significant in adjusted analyses (OR, 1.04; 95% CI, 0.99-1.10; $P = .09$). Race/ethnicity was found to significantly modify the relationship between neighborhood-level poverty and prevalent asthma ($P = .004$ for the interaction between Hispanic ethnicity and neighborhood-level poverty), with neighborhood-level poverty as a significant risk factor among non-Hispanics and Puerto Ricans in adjusted analyses but protective among Hispanics (Table II). Sensitivity analyses, including whether the child received well-child care in the past year or was uninsured at any point, did not materially change the results of these analyses or those of residence in an urban neighborhood (data not shown).

Individual-level household poverty. In unadjusted analyses a 1-unit decrease in the household income to poverty ratio was associated with a 7% increase in the odds of prevalent asthma (95% CI, 1.05-1.10; $P < .001$), with similar results in the model that adjusted for race/ethnicity, urban/rural status, region, age,

TABLE II. Predictors of current asthma

	Crude			Adjusted*		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Overall						
Race/ethnicity						
White	Reference					
Black	1.95	1.70-2.23	<.001	1.87	1.59-2.19	<.001
Hispanic	0.91	0.78-1.07	.26	1.02	0.85-1.23	.81
Puerto Rican	2.33	1.83-2.95	<.001	2.38	1.82-3.11	<.001
Asian	0.83	0.65-1.06	.13	1.01	0.79-1.30	.93
Urbanization						
Urban	Reference					
Suburban	1.03	0.90-1.19	.66	1.14	0.97-1.33	.11
Medium metro	0.97	0.83-1.14	.72	1.05	0.88-1.24	.60
Small metro/rural	1.00	0.85-1.16	.95	1.10	0.92-1.31	.30
Region						
Northeast	Reference					
Midwest	0.93	0.79-1.11	.43	0.98	0.82-1.16	.81
South	0.87	0.75-1.01	.06	0.85	0.73-0.99	.40
West	0.77	0.66-0.91	.002	0.90	0.76-1.07	.25
Birth outside the United States	0.32	0.23-0.45	<.001	0.33	0.24-0.47	<.001
Household poverty†	1.07	1.05-1.10	<.001			
Neighborhood poverty‡	1.10	1.05-1.14	<.001	1.04	0.99-1.10	.09
Hispanics						
Urbanization						
Urban	Reference					
Suburban	1.21	0.88-1.66	.24	1.13	0.81-1.57	.48
Medium metro	1.21	0.85-1.72	.28	1.25	0.88-1.78	.22
Small metro/rural	1.08	0.71-1.64	.72	1.11	0.72-1.70	.64
Household poverty†	0.95	0.89-1.01	.09			
Neighborhood poverty‡	0.90	0.83-0.98	.02	0.90	0.83-0.98	.02
Non-Hispanics and Puerto Ricans						
Urbanization						
Urban	Reference					
Suburban	0.93	0.79-1.09	.37	1.13	0.95-1.36	.17
Medium metro	0.88	0.73-1.05	.15	1.01	0.83-1.22	.93
Small metro/rural	0.91	0.76-1.08	.28	1.07	0.88-1.30	.48
Household poverty†	1.10	1.07-1.14	<.001			
Neighborhood poverty‡	1.20	1.14-1.26	<.001	1.09	1.02-1.16	.008

*Adjusted for age, sex, race/ethnicity, region, neighborhood-level poverty, urban/rural status, and birth outside the United States.

†One-unit increase in ratio of household income to the poverty line.

‡Ten percentage point increase in households living below the poverty line.

sex, and birth in the United States (OR, 1.06; 95% CI, 1.03-1.09; $P < .001$). As was the case for neighborhood-level poverty, Hispanic ethnicity significantly modified the relationship between household poverty and prevalent asthma ($P = .002$), and household poverty was a risk factor for asthma among non-Hispanics and Puerto Ricans (OR, 1.07; 95% CI, 1.03-1.10; $P < .001$) but not Hispanics (OR, 1.00; 95% CI, 0.94-1.07; $P = .94$) in adjusted analyses.

When both neighborhood- and individual-level poverty were included in the model, neighborhood-level poverty was no longer a significant predictor of prevalent asthma in the overall or stratified models, but individual-level poverty remained an independent predictor overall and among non-Hispanics and Puerto Ricans (see Table E3 in this article's Online Repository at www.jacionline.org).

Residence in an urban neighborhood. There were no differences in asthma prevalence in suburban, small-town, and rural neighborhoods compared with urban neighborhoods in either crude or adjusted analyses overall or in analyses stratified by Hispanic ethnicity (Table II), and residence in an urban area did not increase the association between race/ethnicity and asthma prevalence (data not shown). Moreover, living in an urban environment did not increase the association between neighborhood-level poverty and asthma prevalence ($P = .62$).

Asthma morbidity

Black race, Puerto Rican ethnicity, and lower household income were strong independent risk factors for asthma exacerbation and emergency department visits for asthma (Tables III and IV and see Table E3). Neighborhood poverty and urban/rural status were not risk factors in adjusted analyses, with the exception of a protective effect of residence in small metro/rural areas compared with urban areas for emergency department visits in fully adjusted models of the overall population and among non-Hispanics and Puerto Ricans (see Table E3).

DISCUSSION

Although it has long been thought that the prevalence of asthma is high among children living in poor urban neighborhoods in the

TABLE III. Predictors of asthma episode

	Crude			Adjusted*		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Overall						
Race/ethnicity						
White	Reference					
Black	1.71	1.45-2.01	<.001	1.64	1.36-1.97	<.001
Hispanic	0.78	0.65-0.95	.01	0.84	0.68-1.05	.13
Puerto Rican	2.32	1.67-3.22	<.001	2.40	1.66-3.47	<.001
Asian	0.74	0.51-1.08	.11	0.93	0.63-1.36	.70
Urbanization						
Urban	Reference					
Suburban	1.02	0.85-1.22	.83	1.09	0.88-1.34	.43
Medium metro	1.02	0.84-1.26	.78	1.09	0.87-1.35	.46
Small metro/rural	0.99	0.82-1.19	.89	1.03	0.83-1.29	.77
Region						
Northeast	Reference					
Midwest	1.01	0.80-1.28	.93	1.07	0.84-1.37	.58
South	0.99	0.80-1.21	.89	1.01	0.82-1.24	.94
West	0.82	0.66-1.02	.07	1.00	0.79-1.26	.98
Birth outside the United States	0.31	0.20-0.47	<.001	0.34	0.22-0.53	<.001
Household poverty†	1.06	1.02-1.10	.003			
Neighborhood poverty‡	1.06	1.00-1.11	.04	1.02	0.96-1.09	.50
Hispanics						
Urbanization						
Urban	Reference					
Suburban	0.95	0.63-1.45	.82	0.89	0.57-1.39	.61
Medium metro	1.26	0.87-1.84	.21	1.08	0.93-1.95	.12
Small metro/rural	0.88	0.51-1.54	.66	0.87	0.50-1.52	.63
Household poverty†	0.98	0.92-1.03	.4			
Neighborhood poverty‡	0.9	0.79-1.02	.09	0.91	0.80-1.03	.13
Non-Hispanics and Puerto Ricans						
Urbanization						
Urban	Reference					
Suburban	0.94	0.76-1.15	.53	1.12	0.88-1.42	.36
Medium metro	0.93	0.74-1.17	.53	1.05	0.81-1.36	.70
Small metro/rural	0.91	0.74-1.13	.39	1.05	0.82-1.35	.70
Household poverty†	1.09	1.05-1.14	<.001			
Neighborhood poverty‡	1.15	1.08-1.23	<.001	1.05	0.97-1.13	.20

*Adjusted for age, sex, race/ethnicity, region, neighborhood-level poverty, urban/rural status, and birth outside the United States.

†One-unit increase in ratio of household income to the poverty line.

‡Ten percentage point increase in households living below the poverty line.

United States, the prevalence of asthma in these neighborhoods throughout the United States has, surprisingly, not been described. Moreover, the relative contribution of race/ethnicity and household poverty versus other contextual neighborhood-level factors to asthma disparities related to the inner city remains unclear. Here we show that although some inner-city areas have high rates of asthma, particularly in the Midwest and Northeast, other nonurban poor areas have equal or higher asthma prevalence. Overall, black race, Puerto Rican ethnicity, and poverty rather than residence in an urban area *per se* are the major risk factors for prevalent asthma. These findings suggest that the concept of inner-city asthma might need to be refined.

Original reports heralding the phenomenon of inner-city asthma were based on findings of very high asthma morbidity and mortality in several cities, including Baltimore, Chicago, and New York City, and further research documented that poor neighborhoods in these cities were particularly affected.[1,5,7,8,19] These urban areas were also disproportionately home to ethnic minorities, particularly non-Hispanic blacks and Puerto Ricans, who were known to be at risk for asthma.[4] However, early research found conflicting results about whether racial/ethnic disparities were independent of socioeconomic factors.[3,6,20] Since that time, black race and Puerto Rican ethnicity have become clear risk factors for asthma, although how much this is due to environmental exposures, including urban exposures, or to underlying susceptibility remains unknown. Race is a complex concept that is informed by genetic, cultural, and historical factors, and thus it can be hard to parse genetic from environmental risk factors. Degree of African ancestry has been associated with asthma,[29-31] suggesting a genetic explanation, although it can be difficult to fully account for confounding by socioeconomic status, even in genetic analyses,[32,33] particularly because disparities in wealth, educational opportunities, family structure, and employment by race/ethnicity are even higher than what is represented by income[34] and can correlate with ancestry. Here, in a very large and nationally representative data set, we found that black race and Puerto Rican ethnicity were strong risk factors for prevalent asthma and asthma morbidity independent of income, neighborhood-level poverty, and residence in an urban setting, but we cannot exclude residual confounding as an explanation for the association between race/ethnicity and asthma.

TABLE IV. Predictors of asthma ED visit

	Crude			Adjusted*		
	OR	**95% CI**	***P* value**	**OR**	**95% CI**	***P* value**
Overall						
Race/ethnicity						
White	Reference					
Black	4.07	3.03-5.46	<.001	3.45	2.45-4.87	<.001
Hispanic	1.41	0.98-2.01	.06	1.24	0.81-1.90	.31
Puerto Rican	5.41	3.23-9.04	<.001	4.48	2.64-7.58	<.001
Asian	0.89	0.46-1.73	.74	0.96	0.48-1.92	.90
Urbanization						
Urban	Reference					
Suburban	0.61	0.41-0.89	.01	0.75	0.47-1.18	.21
Medium metro	0.88	0.60-1.29	.52	1.06	0.70-1.58	.79
Small metro/rural	0.51	0.35-0.74	<.001	0.66	0.43-1.02	.06
Region						
Northeast	Reference					
Midwest	0.74	0.49-1.12	.16	0.89	0.60-1.32	.56
South	0.82	0.58-1.16	.25	0.82	0.58-1.16	.25
West	0.66	0.43-1.00	.049	0.80	0.51-1.24	.31
Birth outside the United States	0.36	0.19-0.66	.001	0.38	0.19-0.75	.005
Household poverty†	1.22	1.13-1.31	<.001			
Neighborhood poverty‡	1.24	1.14-1.36	<.001	1.04	0.93-1.16	.49
Hispanics						
Urbanization						
Urban	Reference					
Suburban	0.67	0.30-1.48	.32	0.70	0.29-1.68	.42
Medium metro	1.08	0.52-2.21	.84	1.22	0.61-2.46	.57
Small metro/rural	0.65	0.20-2.08	.46	0.79	0.24-2.56	.69
Household poverty†	1.06	0.90-1.26	.49			
Neighborhood poverty‡	1.04	0.83-1.32	.71	1.07	0.86-1.33	.50
Non-Hispanics and Puerto Ricans						
Urbauization						
Urban	Reference					
Suburban	0.55	0.35-0.86	.008	0.75	0.44-1.26	.28
Medium metro	0.80	0.52-1.23	.31	1.02	0.64-1.63	.93
Small metro/rural	0.45	0.31-0.67	<.001	0.65	0.41-1.03	.07
Household poverty†	1.27	1.16-1.38	<.001			
Neighborhood poverty‡	1.34	1.22-1.48	<.001	1.03	0.90-1.18	.65

ED, Emergency department.

*Adjusted for age, sex, race/ethnicity, region, neighborhood-level poverty, urban/rural status, and birth outside the United States.

†One-unit increase in ratio of household income to the poverty line.

‡Ten percentage point increase in households living below the poverty line.

Residence in urban areas, a potential risk factor for asthma hypothesized to be mediated by exposure to indoor and outdoor pollution, pest allergens, and violence and other stressful life events,[20,35] was not found to be a significant risk factor for prevalent asthma or asthma morbidity in this US population–based analysis. The lack of a relationship between urban residence and asthma prevalence, even in crude analyses, might reflect shifting demographics since the inner-city asthma epidemic was first described. Although urban areas have historically tended to be poor, in recent years, the fastest growth in high-poverty areas has occurred in suburban and smaller metropolitan areas, with the slowest growth in the largest cities, as shown by the US Census' Decennial and American Communities Surveys.[36,37] The suburbanization of poverty means that despite continued high rates of concentrated poverty in cities, there are now more poor people living in suburban than urban communities.[36,37] The ethnic composition of poor and urban areas has also shifted, with a so-called "reverse migration" of black populations from Northern cities to the South[38] and an influx of Hispanic populations to urban areas,[39] where they are now the most common ethnic group. These demographic changes challenge the use of "inner city" as interchangeable with black race and mean that focusing on the inner city might not fully capture the population most at risk for asthma. In this survey we estimate that inner-city areas now house only 8% of all children with current asthma compared with the 46% living in suburban or wealthier urban areas, which follows a similar distribution to children as a whole. The environmental factors contributing to asthma in non–inner-city areas, especially poor suburban and medium metro areas, have been relatively less studied than those in the inner city.

In contrast to residence in an urban area, neighborhood- and individual-level poverty were both associated with prevalent asthma, although neighborhood-level poverty was not independent of individual-level household poverty. Poverty can lead to increased risk of asthma through many pathways because known risk factors for asthma are more common in poorer households;

including smoking; shorter duration of breast-feeding; prematurity; higher levels of indoor allergens, such as cockroach and mouse allergens; exposure to outdoor pollution, such as diesel particles; poorer diet; and psychological stress.[40] Poverty (both neighborhood and household) was not a risk factor for non-Puerto Rican Hispanics and was in fact protective, a finding that has been reported in a smaller study in California.[41] Many of the risk factors for asthma that are found in poorer households in general might actually be less common among poorer, less acculturated Hispanic households.[42] Increased acculturation has been linked to higher prevalence of asthma risk factors, including shorter duration of breast-feeding,[43] smoking,[44] prematurity,[45,46] and poor diet,[47] and has been shown to be a risk factor for asthma among Mexican Hispanics.[48,49] Although we adjusted for the subject child's birth outside the United States, our analyses did not adjust for the immigration status of the child's parent, and thus acculturation is a potential explanation for the inverse relationship between poverty and asthma we found among Hispanics, although differences in diagnosis and gene-environment interactions might also play a role.

There are several important caveats to our findings. First, because the research questions addressed in this study could only be answered with a very large study population, the data, by necessity, were obtained by means of self-report. Differences in the likelihood of diagnosis of asthma by race, socioeconomic status, or geography could potentially bias our results. However, assessment of asthma by the NHIS questions is a standard and well-accepted approach to identifying asthma,[50] and self-report of race/ethnicity is considered the gold standard.

Second, there is potential for misclassification of neighborhood characteristics because subjects were surveyed in 2009-2010 but were assigned to year 2000 census tracts in the NHIS survey. These tracts were linked to year 2000 census data for poverty and year 2005 urban/rural definitions. We expect that any changes in distribution of neighborhood-level poverty over the past decade, leading to misclassification of neighborhood-level poverty, are likely to lead to a bias toward the null in our analyses of the relationship between neighborhood-level poverty and asthma, whereas urban/rural status is unlikely to change substantially over 4 to 6 years.

Finally, with regard to asthma morbidity, the outcome measures were fairly crude, and there was less power than for analyses of asthma prevalence overall. Therefore we cannot exclude the possibility that residence in an urban area and poverty might have a stronger role in asthma morbidity than prevalent asthma. In addition, access to care, including emergency care, might explain some of our results, particularly the finding that those living in a rural area were less likely to have emergency department visits for asthma. More research is needed to understand how urban/rural status might affect other measures of asthma morbidity and asthma severity.

These limitations, however, are countered by the study's strengths, which are that it is representative of the US population and of sufficient size to disentangle the effects of race/ethnicity, neighborhood-level poverty, and urban residence on asthma.

In conclusion, our work suggests that the concept of inner-city asthma might need to be revised. Focusing only on urban areas could miss communities that are also at high risk of asthma, particularly those with high concentrations of black, Puerto Rican, and poor children. This work highlights the need for a broad view of asthma disparities to develop the research and public health measures that are most likely to be effective in preventing and managing asthma.

Key messages

- Although the prevalence of asthma is high in some US inner cities, it is equally high in some poor nonurban areas.
- Taking the United States as a whole, living in an urban neighborhood is not associated with increased asthma prevalence.

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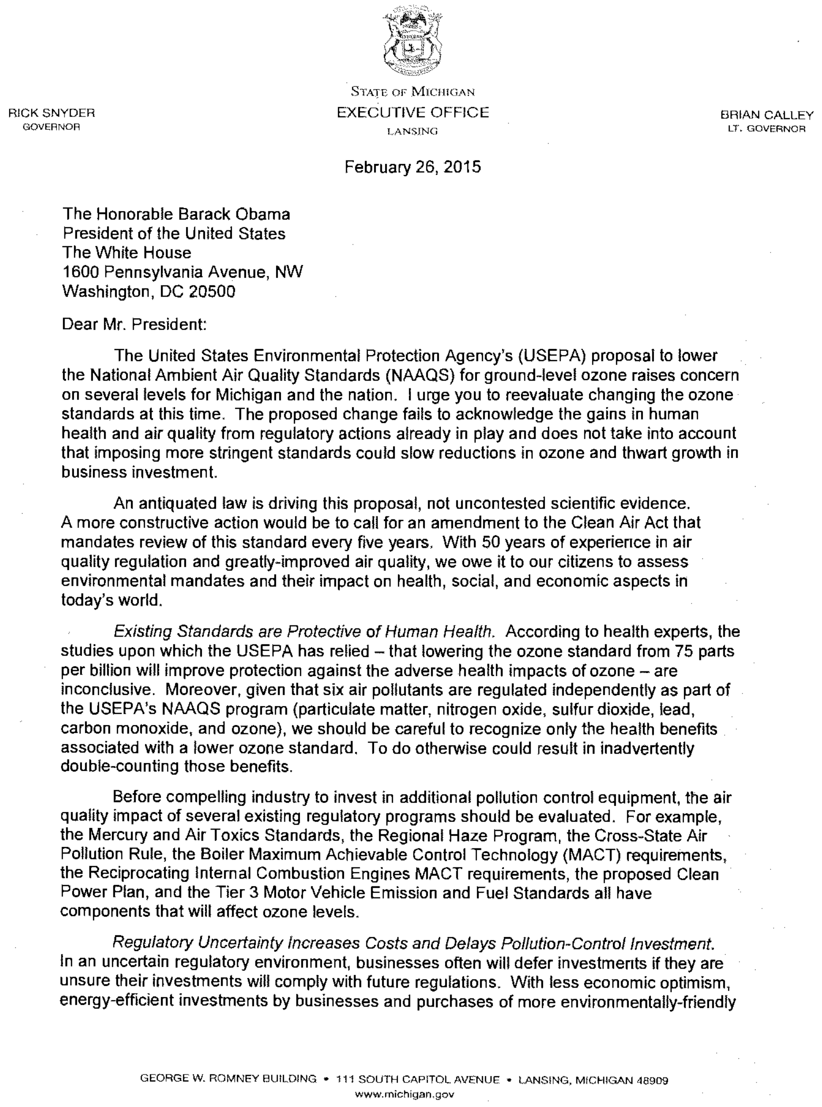
SUBMITTED BY REPRESENTATIVE JOHN R. MOOLENAAR



STATE OF MICHIGAN
EXECUTIVE OFFICE
LANSING

RICK SNYDER
GOVERNOR

BRIAN CALLEY
LT. GOVERNOR

February 26, 2015

The Honorable Barack Obama
President of the United States
The White House
1600 Pennsylvania Avenue, NW
Washington, DC 20500

Dear Mr. President:

The United States Environmental Protection Agency's (USEPA) proposal to lower the National Ambient Air Quality Standards (NAAQS) for ground-level ozone raises concern on several levels for Michigan and the nation. I urge you to reevaluate changing the ozone standards at this time. The proposed change fails to acknowledge the gains in human health and air quality from regulatory actions already in play and does not take into account that imposing more stringent standards could slow reductions in ozone and thwart growth in business investment.

An antiquated law is driving this proposal, not uncontested scientific evidence. A more constructive action would be to call for an amendment to the Clean Air Act that mandates review of this standard every five years. With 50 years of experience in air quality regulation and greatly-improved air quality, we owe it to our citizens to assess environmental mandates and their impact on health, social, and economic aspects in today's world.

Existing Standards are Protective of Human Health. According to health experts, the studies upon which the USEPA has relied – that lowering the ozone standard from 75 parts per billion will improve protection against the adverse health impacts of ozone – are inconclusive. Moreover, given that six air pollutants are regulated independently as part of the USEPA's NAAQS program (particulate matter, nitrogen oxide, sulfur dioxide, lead, carbon monoxide, and ozone), we should be careful to recognize only the health benefits associated with a lower ozone standard. To do otherwise could result in inadvertently double-counting those benefits.

Before compelling industry to invest in additional pollution control equipment, the air quality impact of several existing regulatory programs should be evaluated. For example, the Mercury and Air Toxics Standards, the Regional Haze Program, the Cross-State Air Pollution Rule, the Boiler Maximum Achievable Control Technology (MACT) requirements, the Reciprocating Internal Combustion Engines MACT requirements, the proposed Clean Power Plan, and the Tier 3 Motor Vehicle Emission and Fuel Standards all have components that will affect ozone levels.

Regulatory Uncertainty Increases Costs and Delays Pollution-Control Investment. In an uncertain regulatory environment, businesses often will defer investments if they are unsure their investments will comply with future regulations. With less economic optimism, energy-efficient investments by businesses and purchases of more environmentally-friendly

President Obama
Page 2 of 2
February 26, 2015

appliances and motor vehicles by consumers may be delayed, causing a counterproductive result. Lower investments put drag on the economy, and delayed use of more environmentally-friendly appliances and vehicles curtails improvements in air quality. Public resources also become strained as state regulatory agencies must frequently revise air regulations and strategies to address standards in flux.

Furthermore, as areas become newly-designated as "nonattainment," both public and private resources are diverted to emission-reduction efforts, impeding growth of our economy. The siting of new natural gas plants, resulting from new requirements to reduce greenhouse gas emissions, will be more challenging and expensive – to the point of being prohibitive in "nonattainment" areas. In Michigan, we are taking action to establish policies balancing economic growth with environmental protection.

Enclosed is the technical submittal from Dan Wyant, Director, Michigan Department of Environmental Quality (MDEQ) in response to the proposed NAAQS for ozone published in the *Federal Register* on December 17, 2014 (79 *Federal Register* 75234).

I look forward to working together in a way that considers the long-term health of our state, the nation, the economy, and the environment.

Sincerely,

Rick Snyder

Rick Snyder
Governor

Enclosure
cc/enc:
- Ms. Gina McCarthy, Administrator, USEPA
- Ms. Janet McCabe, Acting Assistant Administrator, Office of Air and Radiation, USEPA
- Dr. Susan Hedman, Regional Administrator, USEPA, Region 5
- Mr. Dan Wyant, Director, MDEQ

THE MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY'S COMMENTS ON THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY'S PROPOSED RULE TO REVISE THE NATIONAL AMBIENT AIR QUALITY STANDARDS FOR OZONE

Docket ID No. EPA-HQ-OAR-2008-0699
February 26, 2015

The Michigan Department of Environmental Quality (MDEQ) respectfully submits the following comments on the United States Environmental Protection Agency's (USEPA) proposed National Ambient Air Quality Standards (NAAQS) for ozone published in the *Federal Register* on December 17, 2014 (79 *Federal Register* 75234). As the USEPA undertakes the challenging task of reviewing and potentially revising the ozone NAAQS, we believe there are some very important details that should not be overlooked in the final drafting of the rule and, thus, submit the following for your review and consideration.

Primary and Secondary Standards

The USEPA has requested comment on a range between 60 and 75 (the current standard) parts per billion (ppb) for the primary ozone standard. In support, the proposal references studies that indicate there are impacts on human physiology at all levels for which comment is being sought. The MDEQ has reviewed the referenced studies, and acknowledges that there are measurable effects of ozone in the form of lung function decrement at exposure levels ranging from well above the current standard (120 ppb) to well below (40 ppb); however, the evidence of adverse effects with exposures below 75 ppb seems much too tenuous to justify lowering the standard, given the effect a lower standard would have on the regulated community as well as Michigan's economy. For example, many of the studies cited, when given the margin of error, indicate the possibility of no measureable effect. Hence, the MDEQ believes the evidence is inadequate to justify modifying the ozone standard from its current level of 75 ppb. Further support for this argument can be found in literature. Smith, *et al.* (Inhalation Toxicology, 2009; 21(S2): 37-61), contends that "estimates of the association between ozone and mortality, based on time-series epidemiologic analyses of daily data from multiple cities, reveal important still unexplained inconsistencies and show sensitivity to modeling choices and data selection." In addition, Goodman, *et al.* (J Appl Toxicol, 2014 May; 34(5): 516-24), indicated that evaluation of controlled ozone exposure studies "do not demonstrate a causal association between ozone concentrations in the range of the current NAAQS and adverse effects on lung function."

At a minimum, the studies referenced above, and others like them, indicate the science is not settled on this issue. Moreover, it appears that many of the studies referenced in the proposal were already considered when determining the 2008 ozone standard, with few since 2008. The proposal does not explain why a reinterpretation of previously-relied upon studies is justified. Additionally, the number of studies rationalizing a more-stringent ozone standard remains low and, therefore, unconvincing. There is also insufficient evidence indicating the averaging times and methods currently employed are inadequately protective. The MDEQ encourages the USEPA to rely on sound science when finalizing the primary standard and to not modify the current standard of 75 ppb unless a significant number of pertinent, quality studies have been conducted since the 2008 ozone standard was evaluated and established.

The MDEQ believes the secondary standard should be kept equal to the primary standard and does not support the use of the W126 index. The W126 index would be much more difficult to effectively implement, and the added complexity of using the index has not been adequately shown to be necessary. The proposal indicates the W126 index can be related to a secondary standard using the same units (ppb) as the primary standard. In that case, leaving the primary and secondary standard equal will result in less confusion for stakeholders, including the general public, and will allow for a more effective implementation of the standard.

Background

Background ozone concentrations are of legitimate concern when considering revising the standard to a more stringent level, especially bearing in mind that ozone occurs naturally and can also be transported from other countries. The USEPA's proposal indicates that volatile organic compound (VOC) emissions from natural sources "comprise around 70 percent of total VOC emissions nationally, with a higher proportion during the ozone season and in areas with more vegetative cover." Of man-made VOC emissions, the USEPA estimates that industrial processes account for 57 percent and mobile sources account for 39 percent. Further, 60 percent of man-made nitrogen oxides (NO_x) emissions are estimated (by the USEPA) to be attributed to on- and non-road mobile sources. To establish a standard lower than 75 ppb when the states have little or no ability to control greater than 50 percent of VOC and NO_x emissions, would make compliance with the standard using regulatory mechanisms available to the states nearly impossible.

Guidance Time Frames/Submittals

The timeliness of the USEPA-issued guidance with regard to the final ozone rule, including implementation and designation guidance, is of great concern to the MDEQ. Due to the deadlines and process requirements placed on state agencies, we believe that the proposed time frames for guidance issuance are too long, leaving inadequate time for states to complete their obligations under the Clean Air Act (CAA). If the USEPA does not issue guidance documents until one year after promulgation of the rule, it will be much more difficult for states to complete their CAA obligations—especially the Section 110 requirements. The MDEQ urges the USEPA to issue implementation guidance as soon as possible and certainly not more than six months after promulgation of the final rule.

For designation recommendations, the MDEQ requests that the USEPA reconsider the four-month delay in guidance issuance referred to in the proposed rule and instead issue designation recommendation guidance simultaneously with promulgation of the NAAQS final rule. Delay in guidance availability makes meeting the time frame for submittal of designation recommendations much more burdensome for states.

If a secondary standard is promulgated that is different from the primary, the MDEQ recommends that the attainment demonstration deadline for states under Section 110 be automatically extended by 18 months. In addition, we believe the guidance should be issued within six months of promulgation due to the complexities created by having a secondary standard that is different from the primary.

Designations

The CAA does not include a provision for the designation of "attainment/unclassifiable" areas. Therefore, for any future designations, the MDEQ requests that the USEPA make designations based solely on those classifications (nonattainment, attainment, or unclassifiable) specified in the CAA.

General

A revision of the ozone standard to lower the threshold level would most certainly result in more designated nonattainment areas in many regions of the country. Of concern is the effect a lower ozone standard would have on a state's ability to comply with other USEPA regulations, including the Mercury and Air Toxics Standards (MATS), the proposed Clean Power Plan (CPP), the Cross-State Air Pollution Rule (CSAPR), and others. An increase in nonattainment areas would create significant obstacles in siting and permitting new natural gas combined cycle (NGCC) plants due to new source review requirements that include offsets and Lowest Achievable Emissions Rate. Such plants will play an integral role in compliance with the CPP and MATS rules. A new NGCC plant must be sited both where there is adequate access to natural gas infrastructure and transmission lines and near population centers/larger cities, which, although designated attainment under the current ozone standard, would likely be designated nonattainment with a lower ozone standard.

In addition, the MDEQ has questions with regard to how the USEPA is counting the benefits of a revised ozone standard. According to the proposal, the cost-benefit analysis quantifies and monetizes the benefits of reducing particulate matter (PM). However, it appears that the benefits of PM reductions have also been counted in the Regulatory Impact Analysis for the $PM_{2.5}$ NAAQS, CSAPR, sulfur dioxide NAAQS, MATS, Boiler Maximum Achievable Control Technology (MACT), CPP, reciprocating internal combustion engine MACT, and the Tier III vehicle and fuel standards. It is unclear whether these benefits are being double counted as the same reductions across multiple rules. Double counting would be disingenuous—drastically inflating the benefits of the rule. We, therefore, urge the USEPA to count only the benefits of ozone reductions associated with a revised standard, not the incidental benefits of other pollutants, such as PM, or the reductions that have already been counted in other recent USEPA proposed or final rules.

Lastly, given the complex chemistry of ozone and the disparate impact of ozone precursor emissions within cities and downwind, the actual benefits and disbenefits of reducing precursor emissions should be weighed in terms of the effect on differing NO_x/VOC ratios in the various airsheds.

Air Quality Index

Forecasting the Air Quality Index (AQI) for ozone is not an exact science. With the current limitations, it is important to provide a range large enough to reasonably predict ozone concentrations for the following day. Ideally, each AQI category would have a 20 ppb or greater range; however, that is not possible with the constraints in the USEPA's proposed breakpoints. Within the revised standard as proposed, the MDEQ recommends that the ozone breakpoints be established as depicted in the last column of the table below; however, if the standard remains 75 ppb, we support retaining the current AQI.

Table 1

AQI Category	Values	Existing	USEPA Recommended Breakpoints (ppb)	MDEQ Recommended Breakpoints (ppb)
Good	0-50	0-59	0-49 or 54	0-49
Moderate	51-100	60-75	50 or 55-65 or 70	50-70 (21 ppb spread)
Unhealthy for Sensitive Groups	101-150	76-95	66 or 71-85	71-85 (15 ppb spread)
Unhealthy	151-200	96-115	86-105	86-105 (20 ppb spread)
Very Unhealthy	201-300	116-374	106-200	106-200
Hazardous	301-500	375+	201+	201+

Monitoring and Photochemical Assessment Monitoring Station

Several monitoring revisions proposed as part of the new ozone standard merit a closer look prior to the standard's finalization. One such issue is whether enhanced photochemical assessment monitoring station (PAMS) measurements should be co-located at existing national core (NCore) sites. While we believe it is laudable to leverage sites where data is already being collected, it is unclear whether NCore sites adequately meet the objectives of the PAMS program. Depending on the modeling domain chosen, there may not be NCore sites located in areas of interest/need, and the current NCore network may not be adequate to depict boundary conditions or areas of maximum emissions. For these reasons, the selection of PAMS sites should not be made until there has been formal consultation with the USEPA and state, local, and tribal modelers; and this consultation should not occur until nonattainment area modeling domains can be chosen. Even then, it is paramount that flexibility be given in the selection of PAMS sites. The proposed rule states that "To account for these situations, the EPA is also proposing to provide the EPA Regional Administrator the authority to approve an alternative location…." The MDEQ believes that this authority should come with an understanding that if alternative sites are still required to be fully outfitted, the cost would be dramatically more expensive than outfitting an NCore site where some infrastructure and instrumentation already exist. The Regional Administrator in exercising this authority should rely on the existing Annual Network Review process rather than a separate waiver procedure.

With regard to PAMS instrumentation, the USEPA proposes to require that PAMSs collect speciated VOC samples, either by employing a continuous, automatic gas chromatograph (auto-GC) or by utilizing summa canister measurements integrated over the course of a number of hours. The MDEQ supports the use of auto-GCs, provided the USEPA allocates adequate funding to purchase and operate the instruments. However, we strongly suggest that procedures be developed by the USEPA to ensure that the auto-GCs collect the full TO-15 suite of air toxic VOCs in addition to the PAMS suite. There are currently 13 VOC species that overlap the two suites, but the overlap does not include many of the higher-toxicity compounds, including methyl ethyl ketone and carbon tetrachloride. Including the measurement of the TO-15 suite of compounds would conform with PAMS rationale number six to provide additional measurements of selected criteria and non-criteria pollutants to be used for evaluating population exposure to air toxics. Given this objective and the cost of auto-GCs, it would be unwise/wasteful to sample only PAMS species or let the auto-GCs sit idle during the months not conducive for ozone formation. We agree with the USEPA's suggested methodology for carbonyls, as it is congruent with the established method for measuring air toxics, namely TO-11.

In addition, the ozone proposal solicits comment on monitoring NO_x at PAMS sites, specifically adding nitrogen dioxide (NO_2) monitoring to the total reactive nitrogen oxides (NO_y) already being conducted at NCore stations. The proposal states that the NO_2 monitoring should be based on new technologies and not based on NO_x minus the nitric oxide (NO) calculation. The USEPA does not give a compelling reason why the NO_x minus NO methodologies are inadequate. While the proposal includes information about interferences due to nitrous oxide (NO_z) compounds, one must recognize that given the resolution of photochemical grid models, that vary from 4 to 32 kilometers, the impact of NO_z interferences would be very small compared to other modeling uncertainties such as emission inventories and mixing heights. The increased emphasis on NO_2 monitoring is especially puzzling given it was for photochemical modeling purposes that states were mandated to monitor NO_y in lieu of NO_2 at NCore sites. Regardless, given the close relationships between NO_x and NO_y, funding for enhanced oxides of nitrogen monitoring might better be spent on other aspects of monitoring, including auto-GCs.

Regarding meteorological measurements, the photochemical modeling community has a long history of relying upon National Weather Service (NWS) measurements for mixing heights and precipitation as these parameters generally vary little over the distances that are typical to nearby airports. As such, the MDEQ does not see a wholesale need for ceilometers or rain buckets at PAMS. In the instance where modeling domains have meso- or micro-scale meteorological features that are not properly characterized by existing NWS measurements, instrumentation could be added to PAMS sites on a case-by-case basis.

The USEPA is also proposing to add nitrogen oxide-chemiluminescence methodology as a second federal reference method (FRM) for ozone. While the MDEQ does not have a strong opinion on this portion of the proposal, we believe that the current ozone monitors designated with federal equivalent method status should retain such status without requiring new performance testing against the new proposed FRM.

SUBMITTED BY REPRESENTATIVE THOMAS MASSIE

COMMONWEALTH OF KENTUCKY
OFFICE OF THE GOVERNOR

STEVEN L. BESHEAR
GOVERNOR

700 CAPITOL AVENUE
SUITE 100
FRANKFORT, KY 40601
(502) 564-2611
FAX: (502) 564-2517

November 21, 2014

The Honorable Barack H. Obama
President of the United States
The White House
1600 Pennsylvania Avenue, NW
Washington, D. C. 20502-0001

Dear Mr. President:

I am writing concerning the anticipated Environmental Protection Agency's (EPA) proposed rule related to the ground-level ozone standard. I appreciate the great challenge that EPA faces in setting health-based standards. As you are aware, protecting the health of Kentuckians is of critical importance to me. However, I must share with you the concern I have that the new ozone standard could create a hardship for many of our communities.

I understand the Clean Air Science Advisory Committee has recommended that the EPA adopt a standard within the range of 60-70 parts per billion (ppb). Any point within that range would be below the existing standard of 75 ppb, and any such reduction would have a significant impact.

The impact of the new standard will vary depending whether or not the standard is reduced from the current 75 ppb and how extreme the reduction is. For example, if 60 ppb is promulgated as the new standard, all 29 of the air monitors that Kentucky operates will exceed the standard. If the highest end of the range is selected, nonattainment will be limited to major metropolitan areas. Currently at 75 ppb only one metropolitan area exceeds the standard. This is of critical importance because if a lower standard is selected, counties in Kentucky that have never before experienced the ramifications of a nonattainment designation may be forced into that position.

I must remind you that other EPA rules either finalized or proposed have been touted for their direct or indirect impact of reducing ozone precursors. The Corporate Average Fuel Economy and Tier 3 standards will affect ozone-forming pollutants from the mobile sector. The Clean Power Plan, which was proposed on June 2 of this year, is expected to reduce 407,000-428,000 tons of nitrogen dioxide in 2030 as reported by the EPA. Thus, there are already extant or proposed ancillary standards that will significantly lower ozone-producing criteria pollutants. Therefore, my advisors recommend the ozone standard should remain unchanged for the time being.

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There are many environmental rules driving up costs in Kentucky that will negatively impact the economy. A new ozone standard does not have to contribute to these costs. Kentucky is a manufacturing state. For example, Kentuckians produce many of the vehicles and much of the aluminum and steel manufactured in the U.S., and our manufacturers rely on low-cost electricity to produce these products. I, therefore, ask you to retain the current ozone standard which will continue to protect the health of our citizens without burdening our communities with costly nonattainment compliance programs. The growth of our economy is dependent on it.

Sincerely,

Steven L. Beshear

cc: Gina McCarthy, Administrator
United States Environmental Protection Agency

SUBMITTED BY REPRESENTATIVE GARY PALMER

OFFICE OF THE GOVERNOR

ROBERT BENTLEY
GOVERNOR

STATE CAPITOL
MONTGOMERY, ALABAMA 36130

(334) 242-7100
FAX: (334) 242-3282

STATE OF ALABAMA

February 24, 2015

The Honorable Gina McCarthy
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

RE: Attention - Docket ID No. EPA-HQ-OAR-2008-0699

Dear Administrator McCarthy:

I write to express my deep concerns regarding the proposal by the United States Environmental Protection Agency (EPA) to change the National Ambient Air Quality Standard (NAAQS) for ground-level ozone. I understand that the proposal requests comments on reducing the current standard to within the range of 70 parts per billion (ppb) to 60 ppb, but I believe the estimated effects on the State of Alabama from any change in the ozone NAAQS far outweigh the suggested benefits.

Reduced standards would drastically impact my state. In Alabama, the only county in non-attainment under the current standard just recently reached attainment through hard work and dedication. A further reduction could not only place this county back in non-attainment but also dramatically increase the number of counties designated as such, up to over three-fourths of the state. Specifically, according to data from Alabama's Department of Environmental Management, a 70 ppb standard will likely result in a non-attainment designation for one monitored counties. With a 65 ppb standard, three monitored counties will be designated non-attainment. Under a 60 ppb standard, twelve of thirteen monitored counties will be designated non-attainment. Additionally, this data does not reflect the unmonitored counties that would be designated non-attainment. It is possible that over three-fourths of the state could be designated non-attainment with a 60 ppb standard. For Alabama, this is unacceptable. Our economy simply cannot continue to improve under these unnecessary, federally-mandated restrictions on existing businesses and economic development. Restrictions on the industrial sector in non-attainment areas would severely impede this state's economic progress. In addition, the cost of implementation may very well reach every Alabama citizen through increased energy costs.

The proposed change is premature and needs further study. To the extent the current standard has only been implemented for a few years, businesses have operated under and made plans based on the current standard for too short of a period. Indeed, the implementing regulations for the current standard have not been released to the states to allow submittal of State Implementation Plans (SIPs). Further study is needed to determine the actual benefits of a lower ozone NAAQS. If the current standard has only recently been attained, it is difficult to understand how sufficient data could have been collected, let alone analyzed to show the health impacts of the recently attained levels. Without knowing the impacts of the current standard, I do not understand the reason for additional reductions. Further, if, as the EPA reportedly admits, other environmental regulations will lower ozone emissions, a different ozone standard is unnecessary and will simply harm the economy through non-attainment designations without providing additional benefits.

I support and encourage environmental and public welfare protections but cannot support regulations that are more harmful than beneficial. I request that the current standard remain.

Sincerely,

Robert Bentley

Robert Bentley
Governor

SUBMITTED BY REPRESENTATIVE BRUCE WESTERMAN

IER INSTITUTE FOR ENERGY RESEARCH

instituteforenergyresearch.org

http://instituteforenergyresearch.org/analysis/study-undermines-scientific-basis-epas-ozone-rule/?pfstyle=wp

Study Undermines Scientific Basis for EPA's Ozone Rule

Researchers have long thought that there was a correlation between living in urban areas and asthma prevalence. This is part of a belief that outdoor air pollution, which is often worse in inner-city areas, contributes to asthma development.

However, a new study questions the link between asthma and city living. It shows that once we adjust for other factors, notably race and poverty, whether a person lives in an urban or a non-urban area is not a good predictor of asthma.

This new research calls into question EPA's longstanding belief that people, particularly children, who are exposed to more outdoor air pollution, such as ozone, are at a greater risk for developing asthma. Instead, the researchers found that *poverty* is a greater risk factor for asthma, while living in urban areas (with higher outdoor air pollution) is "not significant."

The finding that poverty has more to do with asthma than living in urban areas undermines EPA's case for lowering national standards for ground-level ozone—a regulation that could be the costliest rule ever proposed.

By making people poorer, EPA's proposed rule could make asthma worse. If this study is correct, then the ozone rule would be inconsistent with EPA's statutory requirement under the Clean Air Act to protect public health with an "adequate margin of safety." It also underscores the need for Congress to force EPA to consider the link between economic costs and public health.

In light of this new evidence, EPA should rescind its proposed ozone rule. This rule could exacerbate the public health problem it is trying to mitigate and impose enormous economic burdens on American families. Moreover, ozone levels are already declining without further regulation, obviating the need for more federal mandates.

Study Questions Long-Held Asthma Link

EPA has long linked outdoor air pollution to asthma attacks, the "development of asthma," and other respiratory conditions. The agency uses the assumed correlation as a pretext for nearly all of its clean air regulations, including its proposed ozone rule.

However, this new study, published in the *Journal of Allergy and Clinical Immunology* by a team of researchers led by Dr. Corinne Keet at the John's Hopkins Children's Center, examined data for 23,065 children across the country. The study concludes: "Although the prevalence of asthma is high in some inner-city areas, this is largely explained by demographic factors and not by living in an urban neighborhood."

In fact, the authors found that *indoor pollution linked to poverty* is a greater risk factor for asthma than living in an urban area, where outdoor air pollution is usually worse. As TIME explains:

> *The new findings still support pollution as a cause for asthma, but it suggests that* ***indoor pollution may be doing more of the harm.***
>
> *"**A lot of what may make a difference is what happens inside the home than outside the home** , especially as we spend so much time indoors these days," says Keet. Allergen exposure from old*

> *housing materials, cockroaches and mice, mold pollution, cleaning supplies, and tobacco smoke may be heavy contributors. [Emphasis mine]*

The authors note in their study that once they controlled for race, ethnicity, and poverty, the correlation between inner-city living and asthma prevalence disappeared:

> *Here we show that although some inner-city areas have high rates of asthma, particularly in the Midwest and Northeast, other non-urban poor areas have equal or higher asthma prevalence. Overall,* ***black race, Puerto Rican ethnicity, and poverty rather than residence in an urban area per se are the major risk factors for prevalent asthma.*** *[Emphasis mine]*

On the next page, the authors offer further explanation:

> ***Residence in urban areas,*** *a potential risk factor for asthma hypothesized to be mediated by exposure to indoor and outdoor pollution, pest allergens, and violence and other stressful life events,* ***was not found to be a significant risk factor for prevalent asthma or asthma morbidity in this US population–based analysis.*** *[Emphasis mine]*

This new study isn't the first to question the science of asthma and air pollution. Last year, Drs. Julie Goodman and Sonja Sax accused EPA of "cherry-picking" studies to support stricter ozone standards. As Goodman and Sax put it, "EPA assumes that ozone causes more health effects than what the science supports."

This latest study casts further doubt on the scientific basis for EPA's ozone rule. In a recent opinion piece for *The Hill,* Dr. Joseph Perrone, chief science officer at the Center for Accountability in Science, was the first to point out how the Hopkins study undermines EPA's science on ozone and asthma:

> *This is science the EPA cannot ignore. If the agency is truly interested in "following the science," it should spend more time addressing real public health threats than imposing costly rules based on dubious science that may only make us poorer and sicker.*

It is important to note that Keet's study examined asthma prevalence, not asthma attacks or any other health effects. EPA cites reductions in both asthma prevalence and asthma attacks to justify its proposed ozone rule.

EPA's Ozone Rule Exacerbates Asthma and Poverty

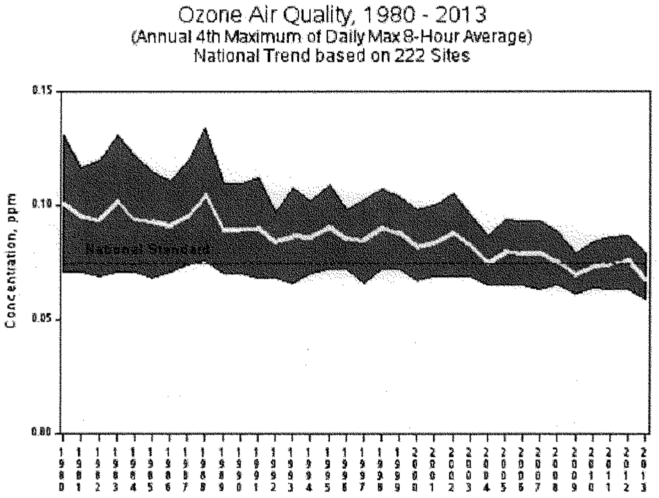
EPA is currently accepting public comments on a proposal to tighten national ozone standards by as much as 20 percent, from 75 parts per billion (ppb) to 60 ppb. EPA Administration Gina McCarthy claims that the proposed rule is necessary because "cutting air pollution to meet ozone standards lowers the risk of asthma."

In fact, EPA may actually make asthma worse by exacerbating poverty. A recent analysis finds that EPA's ozone rule could slash economic growth by $270 billion per year, destroy 2.9 million jobs annually, and reduce household spending by $1,570 per year. That would make EPA's proposal the costliest regulation in U.S. history.

If poverty contributes more to asthma than ozone, EPA's proposal, which could put millions of Americans out of work and slow economic growth, could actually *increase asthma prevalence.* That would make EPA's ozone rule inconsistent with the agency's statutory obligation under the Clean Air Act to protect public health with an "adequate margin of safety."

Ozone Declining Without Further Regulation

Even if EPA's proposed ozone rule didn't threaten public health, it would still be unnecessary because ozone levels are already declining without a tighter standard. According to EPA's own data, ozone levels have declined 33 percent since 1980 alone. The following EPA chart shows national ambient ozone levels between 1980 and 2013:



Ozone Air Quality, 1980 - 2013
(Annual 4th Maximum of Daily Max 8-Hour Average)
National Trend based on 222 Sites

1980 to 2013 : 33% decrease in National Average

Further tightening ozone regulations would likely only increase poverty, which could actually make asthma worse. To protect public health with an "adequate margin of safety," EPA must rescind its proposed rule.

EPA Should Consider Link Between Poverty and Public Health

A major flaw with EPA's ozone rule is that EPA cannot consider the link between economic costs and public health, even though the science shows that poverty worsens public health. In EPA's Regulatory Impact Analysis for its proposed ozone rule, the agency claims "the Clean Air Act and judicial decisions make clear that the economic and technical feasibility of attaining ambient standards are not to be considered in setting or revising [National Ambient Air Quality Standards]," including ozone.

This is problematic, as it seems to conflict with EPA's statutory requirement under the Clean Air Act to protect public health with an "adequate margin of safety." EPA's ozone rule could impose enormous compliance costs, resulting in job losses and reduced economic activity. In other words, the rule could make people poorer, which the science shows makes people less healthy.

Congress should force EPA to consider the link between the economic costs of its regulations and public health outcomes. EPA might still conclude that health benefits outweigh costs, but it would at least force the agency to consider the science on poverty and health.

Conclusion

The new study published in the *Journal of Allergy and Clinical Immunology* found no link between living in an inner city—where outdoor air pollution (including ozone) is generally higher than non-inner-city areas—and asthma prevalence in children. Rather, the study found that *poverty* is more closely linked to asthma than city living, where outdoor air pollution is generally worse. That means EPA's proposed ozone rule, which could be the costliest regulation in U.S. history, could actually make *asthma worse* by making poverty worse. In light of these new findings, EPA should withdraw its proposed ozone rule.

American Forest & Paper Association

AMERICAN WOOD COUNCIL

Statement
American Forest & Paper Association
American Wood Council
House Committee on Science, Space, and Technology
Hearing
"Reality Check: The Impact and Achievability
of EPA's Proposed Ozone Standards"
March 17, 2015

Introduction

The American Forest & Paper Association (AF&PA) serves to advance a sustainable U.S. pulp, paper, packaging, and wood products manufacturing industry through fact-based public policy and marketplace advocacy. AF&PA member companies make products essential for everyday life from renewable and recyclable resources and are committed to continuous improvement through the industry's sustainability initiative - *Better Practices, Better Planet 2020*. The forest products industry accounts for nearly 4 percent of the total U.S. manufacturing GDP, manufactures approximately $210 billion in products annually, and employs nearly 900,000 men and women. The industry meets a payroll of approximately $50 billion annually and is among the top 10 manufacturing sector employers in 47 states.

AF&PA's sustainability initiative - *Better Practices, Better Planet 2020* - is the latest example of our members' proactive commitment to the long-term success of our industry, our communities and our environment. We have long been responsible stewards of our planet's resources. Our member companies have collectively made significant progress in each of the following goals, which comprise one of the most extensive quantifiable sets of sustainability goals for a U.S. manufacturing industry: increasing paper recovery for recycling; improving energy efficiency; reducing greenhouse gas emissions; promoting sustainable forestry practices; improving workplace safety; and reducing water use.

The American Wood Council (AWC) is the voice of North American wood products manufacturing, representing over 75 percent of an industry that provides approximately 400,000 men and women with family-wage jobs. AWC members make products that are essential to everyday life from a renewable resource that absorbs and sequesters carbon. Staff experts develop state-of-the-art engineering data, technology, and standards for wood products to assure their safe and efficient design, as well as provide information on wood design, green building, and environmental regulations. AWC also advocates for balanced government policies that affect wood products.

Background

Under the Clean Air Act, EPA must update its assessment of the latest science and consider *whether* any changes are needed to National Ambient Air Quality Standards (NAAQS) at least every five years. The Administration has significant discretion in determining what is "requisite" to protect public health when setting NAAQS. In fact, in 2011 EPA started a process to reconsider the ozone NAAQS but President Obama intervened and asked Administrator Jackson to withdraw the rule, which she did.

EPA missed its five-year review deadline for the ozone NAAQS in 2013 and was sued by environmental groups. Under a court order, EPA signed a proposed rule on December 1, 2014 to lower the current 75 ppb limit to between 65 and 70 ppb – the rule was published in the Federal Register on December 17, 2014 with a 90 day comment period which ends today, March 17. In the proposal, we were pleased that EPA invited comment on retaining the current standard citing different interpretations of the underlying science. A final rule is due under the court schedule by October 1, 2015 -- a very accelerated pace for a rule of this complexity and importance to the nation.

Position

States should proceed with implementing the 2008 ozone standard first before EPA moves the ozone NAAQS goal posts again. EPA's ill-timed attempt to tighten the ozone NAAQS in 2011 drew focus away from the important tasks of designating areas as non-attainment and then identifying additional controls from mobile and stationary sources through State Implementation Plans (SIPs). In fact, EPA just published on March 6 the 2008 Ozone Implementation rule earlier this month, seven years after it set the new standard, which lays out requirements for SIPs. States, EPA and regulated entities should focus on those designation and implementation efforts. Constantly moving these air quality goal posts creates significant business uncertainty for investments that are critical to our global competitiveness.

Air quality has gotten significantly better over the last several years and will continue to improve due to other EPA rules on the books, such as Boiler Maximum Achievable Control Technology (MACT), even if the ozone NAAQS is not changed. Nitrogen oxide (NOx) and volatile organic compound (VOC) emissions from pulp, paper and wood product mills continue to decline. In fact, NOx emissions are down by over 25% from 2000 to 2012 at pulp and paper mills.

AF&PA and AWC support clean air and realistic, science-based air quality standards. However, the health effect evidence for ozone has not changed significantly since EPA tightened the ozone NAAQS in 2008, so a further change is not justified. EPA continues to rely on studies that reinforce their concerns while ignoring or giving little weight to negative or ambiguous studies. Specifically, there is a lack of definitive evidence linking low levels of ozone exposure – those below the current standard - to adverse health impacts. The evidence on which EPA relies today is no stronger than it was the last time the standard was reviewed in 2008.[1] Furthermore, EPA's new conclusions are not consistent with the majority of the science on the subject.[1,2] EPA's analyses show that few (if any) people would be adversely affected by ozone at the current standard.[3]

U.S. ozone levels are increasingly attributable to natural sources and pollution from other countries which must be considered when EPA reviews the ozone limits. Some ozone is generated naturally from plants, fires, and ozone from the stratosphere that comes into the troposphere. The proportion of ozone coming from other countries as far away as China is steadily increasing and becoming part of the "background." In some places, background concentrations (ozone that originates from natural sources or transported international emissions) contribute to over 80% of total ozone.[4] Even EPA's advisory committee notes the lack of clarity regarding how ozone standards are impacted by background concentrations.[5]

We are pleased EPA has not chosen to set a secondary standard more stringent than the primary standard as well as not propose a new "cumulative form" of the secondary standard instead keeping to the 8-hour form. Our analysis concludes that any cumulative form of the standard, such as the W126 mentioned in the EPA support documents, is redundant with the 8-hour form. In addition, forestry and potential biomass loss from ozone exposure have not been demonstrated below the current concentrations so the current standard is adequately protective of trees and our fiber supply.

Finally, while EPA cannot consider costs when setting the NAAQS, the costs of mistakenly tightening the standard are significant when there is such scientific uncertainty. EPA's own cost benefit analysis would make the ozone rule one of the most expensive air regulations ever at over $15 billion. More complete industry assessments put the economy-wide annual cost ten times higher with significant energy cost increases and job losses. The revisions could place most of the country in nonattainment, putting five times more paper and wood product mills at risk and having to spend over two billion dollars to comply while losing business opportunities due to permit restrictions. Our industry already has invested billions of dollars to help make our air clearer while making products essential for everyday life.

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[1] Gradient (Cambridge, MA) "Long-Term Ozone Exposure and Mortality." Report to Utility Air Regulatory Group. (April 2013); Gradient (Cambridge, MA) "Short-term Ozone Exposure and Mortality." Report to American Forest and Paper Association (December 20, 2013); Gradient (Cambridge, MA) "Long-Term Ozone Exposure and Respiratory Morbidity." Report to American Forest and Paper Association (December 20, 2013).

[2] Honeycutt, Dr. Michael, "Will EPA's Proposed New Ozone Standards Provide Measurable Health Benefits?", National Outlook, Texas Commission on Environmental Quality (TCEQ) PD-020/14/07 (October 2014)

[3] US EPA. August 2014. "Health Risk and Exposure Assessment for Ozone (Final Report)." EPA-452/R-14-004a-e.

[4] US EPA. August 2014. "Policy Assessment for the Review of the Ozone National Ambient Air Quality Standards." EPA-452/R-14-006

Conclusion

Given the significant scientific uncertainties and large economic impacts, AF&PA and AWC recommend that EPA retain the current standard of 75 parts per billion as protective of public health and not set a different secondary standard.

For additional information, please contact
Erik Heilman, Director of Government Affairs
AF&PA
1101 K St. NW, Suite 700
Washington, DC 20005
202-463-2792

Sarah Dodge-Palmer, VP of Government Affairs
AWC
1101 K St NW, Suite 700
Washington, DC 20005
202-462-2788

SUBMITTED BY REPRESENTATIVE FRANK D. LUCAS

AMERICAN FARM BUREAU FEDERATION®
600 Maryland Ave. SW | Suite 1000W | Washington, DC 20024

ph. 202.406.3600
f. 202.406.3606
www.fb.org

March 9, 2015

The Honorable Gina McCarthy
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, D.C. 20460

RE: Docket ID No. EPA-HQ- OAR-2008-0699 – National Ambient Air Quality Standards for Ozone

Dear Administrator McCarthy,

The American Farm Bureau Federation (Farm Bureau) is the nation's largest general farm organization, representing agricultural producers of nearly every type of crop and livestock across all 50 states and Puerto Rico. We have a vital interest in enhancing and strengthening the lives of farmers and ranchers. Farm Bureau appreciates this opportunity to provide comments regarding the proposed revisions to the existing National Ambient Air Quality Standards (NAAQS) for ozone published in the *Federal Register* on Dec. 17, 2014. The proposed revisions tighten primary (health based) and secondary (welfare-based) standards, a move that will impose real and significant costs while providing uncertain and unverified benefits. Farm Bureau is concerned about the difficulty regulating volatile organic compounds (VOCs), nitrogen oxides (NOx), and other potential ozone precursors from agriculture and the chilling effect of these standards on the economy as a whole.

In the presence of heat and sunlight, atmospheric reactions of NOx and VOCs emitted from various biogenic and anthropogenic sources produce ozone. VOCs are defined in 40 CFR 51.100 as "any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions." NOx are created from lightning, soil microbial activity, burning biomass, and fuel combustion. The Clean Air Act directs the EPA to set NAAQS for ozone at a level that is protective of human health and the environment, and to regulate both VOC and NOx emissions as ozone precursors.

For each state with areas not attaining the ozone NAAQS, EPA provides guidance to the state to develop its State Implementation Plan (SIP) to attain the standard by a required attainment date. Since 1970, EPA's strategy to reduce tropospheric ozone levels in nonattainment areas has focused mainly on reducing the total mass of VOC emissions. In the 1990s, the EPA developed a strategy to reduce NOx. The NOx reduction strategy and the VOC reduction strategy have helped decrease ozone levels. Since 1980, ozone forming emissions have already been cut in half and average ozone concentrations have dropped by 33 percent over the same period. EPA just updated ozone standards six years ago. These current standards are behind schedule due to EPA effectively suspending their implementation from 2010-2012 while the Agency unsuccessfully pursued reconsideration. We can expect to see even greater reductions in ground-level ozone as states make up lost ground in putting the current standards into effect.

States are currently committing substantial resources – both in time and money – towards achieving emissions reductions under current ozone standards. Yet, despite over three decades of cleaner air, EPA is now proposing a new stringent range of standards from 70 to 65 parts per billion that would bring vast swaths of the country into nonattainment. In some areas, the proposed range is at or near the level of background ozone that is naturally occurring or internationally transported, pushing even rural counties far from industrial activity into nonattainment. In the past, lower ozone standards were reached by requiring industrial facilities to install control equipment for NOx and VOCs. Large power plants historically have been a relatively cost-efficient way to achieve NOx reduction, but those opportunities are quickly diminishing because the majority of existing coal-fired power plant capacity is equipped with some form of NOx controls and further controls are expected to be installed because of other EPA regulations.

Although a relatively small contributor, agriculture produces VOCs (from pesticides and livestock) and NOx (from engines and other sources) that may be regulated through monitoring and control measures. Restrictions limiting NOx and VOCs may create a significant problem for agriculture. Control measures could be implemented that would: curtail production activities; restrict pesticide applications; designate/limit pesticide application times; eliminate pesticide availability; restrict animal agricultural feeding operations due to emissions from animal waste handling and storage; prescribe costly control measures for animal agriculture; and prescribe costly and wasteful control measures for certain food and agricultural processing industries. The domestic renewable fuels industry (ethanol and biodiesel) could be greatly affected by control measures required for a more stringent standard since they too can contribute to VOCs and NOx during manufacture and use.

Agriculture also will be indirectly impacted by costs passed on to the consumer from special requirements for vehicles and fuels (diesel trucks and farm equipment), restrictive permitting requirements that affect plant expansions, and the loss of federal highway and transit funding. Farming and ranching are energy-intensive businesses. Farmers and ranchers depend on reliable, affordable sources of energy in their daily operations- including using tractors and operating dairy barns, poultry houses and irrigation pumps. For farmers and ranchers that compete in a global economy, higher energy costs and fewer transportation options not only hurt competitiveness, but can determine farm viability and prosperity.

If finalized, EPA's proposed stringent ozone standards could limit business expansion in nearly every populated region of the U.S. and impairs the ability of U.S. companies to create new jobs and agriculture to remain competitive. Local communities will face burdens to commercial, industrial and agricultural activity not only vital to creating jobs, but also to providing tax revenue that support local services like public safety and education. This is of great concern to Farm Bureau, whose mission is not only to increase the viability of farmers and ranchers but to improve the quality of life in rural communities. This proposal's hardship to rural America is real and immediate, while the benefits are unverified and uncertain.

Building a new facility or performing major modifications to certain existing facilities that result in increased ozone concentrations in, or near, a nonattainment area will require permits that meet the most stringent Clean Air Act standard by installing the most effective emission reduction technology regardless of cost. In addition, states are mandated to offset any ozone-forming emissions from new projects or projects undergoing major modifications by reducing emissions from other existing sources in a nonattainment area. If no party is willing to provide offsets, then the project cannot go forward. Nonattainment designation also has profound impact on infrastructure development vital to the agriculture community. Beginning one year from the date of the nonattainment designation, federally-supported highway and transit projects cannot proceed in a nonattainment area unless the state can demonstrate that the project will cause no increase in ozone emissions.

The restrictions do not disappear when an area finally comes into attainment. Instead, former nonattainment areas face a legacy of EPA regulatory oversight. Before a nonattainment area can be redesignated to attainment, EPA must receive and approve an enforceable maintenance plan for the area that specifies measures providing continued maintenance of ozone standards and contingency measures to be implemented promptly if an ozone standard is violated.

In closing, the stringent new ozone standards have the potential for damaging economic consequences across the entire economy and would place serious restrictions on farmers, increasing input costs for things like electricity, fuel, fertilizer and equipment. Further, as ozone standards are ratcheted down closer to levels that exist naturally, more farmers will be forced to abide by restrictions on equipment use and land management, making it harder to stay in business. EPA's own estimates show that a new ozone rule could cost tens of billions of dollars per year and independent estimates indicate that the costs will likely be much higher, putting millions of jobs at risk. A new ozone rule has the potential to be the most costly regulation in our nation's history.

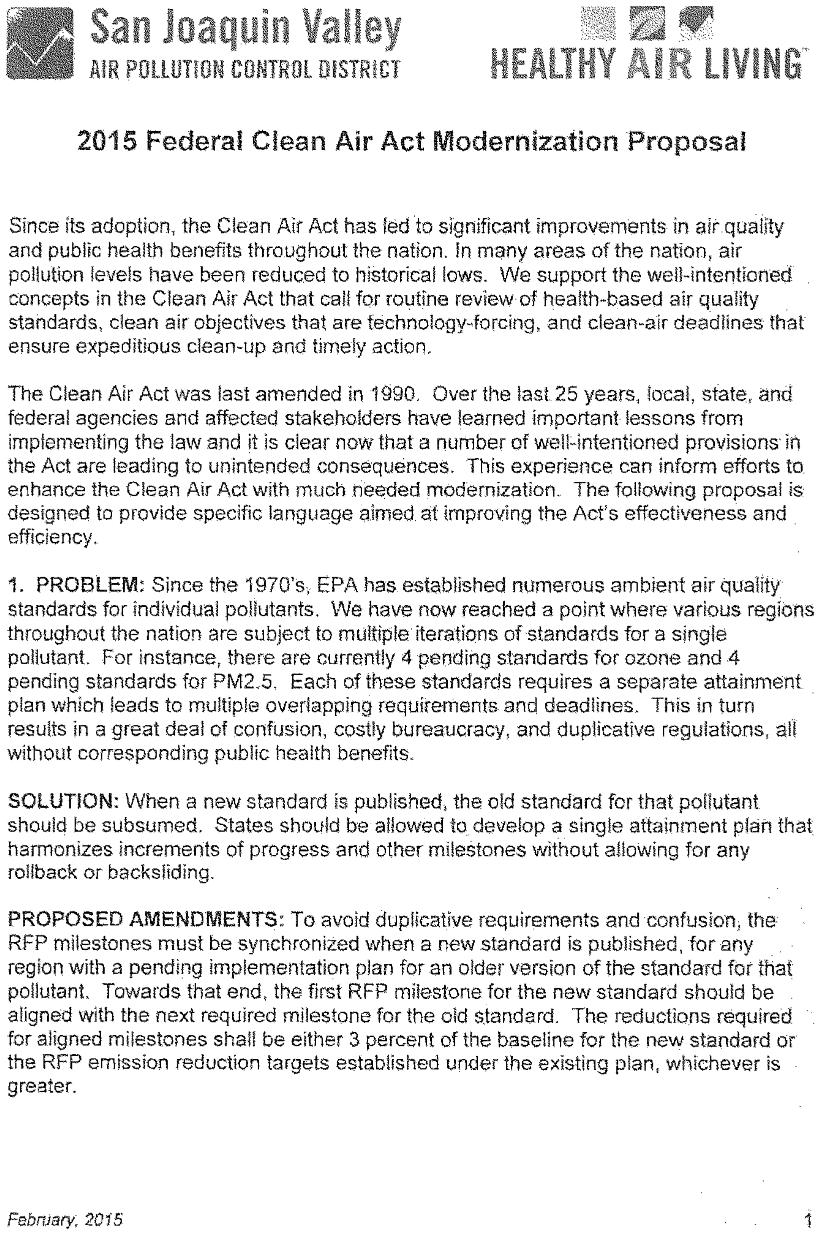
In light of the economic hardship a new ozone standard would cause to farmers throughout the country, including the reduction in funding for crucial civic services, and only providing uncertain benefits, Farm Bureau encourages the EPA to retain the existing ozone standard in the final rule. Our country's farmers cannot afford a stricter ozone standard.

Sincerely,

Dale W. Moore

Dale Moore
Executive Director
Public Policy

SUBMITTED BY COMMITTEE CHAIRMAN LAMAR SMITH



San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

HEALTHY AIR LIVING

2015 Federal Clean Air Act Modernization Proposal

Since its adoption, the Clean Air Act has led to significant improvements in air quality and public health benefits throughout the nation. In many areas of the nation, air pollution levels have been reduced to historical lows. We support the well-intentioned concepts in the Clean Air Act that call for routine review of health-based air quality standards, clean air objectives that are technology-forcing, and clean-air deadlines that ensure expeditious clean-up and timely action.

The Clean Air Act was last amended in 1990. Over the last 25 years, local, state, and federal agencies and affected stakeholders have learned important lessons from implementing the law and it is clear now that a number of well-intentioned provisions in the Act are leading to unintended consequences. This experience can inform efforts to enhance the Clean Air Act with much needed modernization. The following proposal is designed to provide specific language aimed at improving the Act's effectiveness and efficiency.

1. **PROBLEM:** Since the 1970's, EPA has established numerous ambient air quality standards for individual pollutants. We have now reached a point where various regions throughout the nation are subject to multiple iterations of standards for a single pollutant. For instance, there are currently 4 pending standards for ozone and 4 pending standards for PM2.5. Each of these standards requires a separate attainment plan which leads to multiple overlapping requirements and deadlines. This in turn results in a great deal of confusion, costly bureaucracy, and duplicative regulations, all without corresponding public health benefits.

SOLUTION: When a new standard is published, the old standard for that pollutant should be subsumed. States should be allowed to develop a single attainment plan that harmonizes increments of progress and other milestones without allowing for any rollback or backsliding.

PROPOSED AMENDMENTS: To avoid duplicative requirements and confusion, the RFP milestones must be synchronized when a new standard is published, for any region with a pending implementation plan for an older version of the standard for that pollutant. Towards that end, the first RFP milestone for the new standard should be aligned with the next required milestone for the old standard. The reductions required for aligned milestones shall be either 3 percent of the baseline for the new standard or the RFP emission reduction targets established under the existing plan, whichever is greater.

For ozone, add new subsection 182(k) as follows:

(k) RFP Milestone Alignment for Areas with Pending Attainment Plans

Notwithstanding any other provisions of this section, the RFP milestones and emission reduction targets in areas that have submitted a plan to the Administrator for the older version of a standard for the same pollutant being addressed by a new standard shall be set as follows:

The first RFP milestone for the new standard shall be set at the next RFP milestone date for the existing standard addressed in the current plan. Subsequent milestones will be every three years from the first milestone until attainment. The reductions required at the aligned milestones that address more than one standard shall be either 3 percent of the baseline for the new standard or the RFP emission reduction targets established under the current plan for the older standard, whichever is greater.

For particulates, add new subsection 189(c)(4) as follows:

(4) RFP Milestone Alignment for Areas with Pending Attainment Plans

Notwithstanding any other provisions of this section, the RFP milestones and emission reduction targets in areas that have submitted a plan to the Administrator for the older version of a standard for the same pollutant being addressed by a new standard shall be set as follows:

The first RFP milestone for the new standard shall be set at the next RFP milestone date for the existing standard addressed in the current plan. Subsequent milestones will be every three years from the first milestone until attainment. The reductions required at the aligned milestones that address more than one standard shall be either those required for the new standard or the RFP emission reduction targets established under the current plan for the older standard, whichever is greater.

2. PROBLEM: Mobile and stationary sources throughout the nation have now been subject to multiple generations of technology forcing regulations that have achieved significant air quality benefits. Meeting the new standards that approach background concentrations call for transformative measures that require time to develop and implement. These transformative measures require new technologies that in many cases are not yet commercially available or even conceived. The formula-based deadlines and milestones that were prescribed in the Act 25 years ago now lead to mandates that are impossible to meet.

SOLUTION: In establishing deadlines and milestones, the Act should be amended to require control measures that lead to the most expeditious attainment of health based standards while taking into account technological and economic feasibility. These deadlines and milestones should also consider background pollution concentrations and the region's geography, topography, and meteorology that affect pollutant formation and dispersion.

PROPOSED AMENDMENTS:

In relation to RFP targets for ozone, amend subsection 182(b)(1)(A)(ii)(III) as follows:

the plan reflecting a lesser percentage than 15 percent includes all measures that can feasibly be implemented in the area, in light of technological achievability and economic feasibility.

In relation to RFP targets for ozone, amend subsection 182(c)(2)(B)(ii) as follows:

an amount less than 3 percent of such baseline emissions each year, if the State demonstrates to the satisfaction of the Administrator that the plan reflecting such lesser amount includes all measures that can feasibly be implemented in the area, in light of technological achievability and economic feasibility.

In relation to RFP targets for ozone, amend subsection 182(e) as follows:

Each State in which all or part of an Extreme Area is located shall, with respect to the Extreme Area, make the submissions described under subsection (d) of this section (relating to Severe Areas), and shall also submit the revisions to the applicable implementation plan (including the plan items) described under this subsection. ~~The provisions of clause (ii) of subsection (c)(2)(B) of this section (relating to reductions of less than 3 percent), t~~The provisions of paragraphs [6] (6), (7) and (8) of subsection (c) of this section (relating to de minimus [7] rule and modification of sources), ~~and the provisions of clause (ii) of subsection (b)(1)(A) of this section (relating to reductions of less than 15 percent)~~ shall not apply in the case of an Extreme Area. For any Extreme Area, the terms "major source" and "major stationary source" includes [8] (in addition to the sources described in section 7602 of this title) any stationary source or group of sources located within a contiguous area and under common control that emits, or has the potential to emit, at least 10 tons per year of volatile organic compounds.

In relation to RFP targets for particulates, amend subsection 189(c)(1) as follows:

Plan revisions demonstrating attainment submitted to the Administrator for approval under this subpart shall contain quantitative milestones which are to be achieved every 3 years until the area is redesignated attainment and which demonstrate reasonable further progress, as defined in section 7501(1) of this title, and which take into account technological achievability and economic feasibility, toward attainment by the applicable date.

In relation to the attainment deadlines for ozone:

Amend section 181(a) by adding the following new subsection 181(a)(6):

Notwithstanding table 1, if an area is already classified as extreme for an existing standard, then the area shall be classified as extreme at the time of designation for the new standard.

Amend section 181(a) by amending table 1 as follows:

TABLE 1

Area class	***Design value****	***Primary standard attainment date****
Marginal	*0.121 up to 0.138*	*3 years after November 15, 1990*
Moderate	*0.138 up to 0.160*	*6 years after November 15, 1990*
Serious	*0.160 up to 0.180*	*9 years after November 15, 1990*
Severe	*0.180 up to 0.280*	*15 years after November 15, 1990*
Extreme	*0.280 and above*	~~*20 years after November 15, 1990*~~ *As prescribed in section 181(a)(7)*

Amend section 181(a) by adding the following new subsection 181(a)(7):

Areas shall attain the standard as expeditiously as possible with the most effective measures that take into account technological achievability and economic feasibility. The area shall quantify reductions needed to achieve attainment consistent with section 182(e)(5). Every 5 years after the plan is approved by the Administrator, the area shall demonstrate that all measures that are technologically achievable and economically feasible are implemented or will be included in the plan to ensure expeditious implementation. The plan shall also include measures for advancing the development and deployment of new technologies.

Amend section 182(e)(5) as follows:

(5) New technologies
The Administrator may, in accordance with section 7410 of this title, approve provisions of an implementation plan for an Extreme Area which anticipate development of new control techniques or improvement of existing control technologies, and an attainment demonstration based on such provisions.~~*, if the State demonstrates to the satisfaction of the Administrator that—*~~

~~*(A)such provisions are not necessary to achieve the incremental emission reductions required during the first 10 years after November 15, 1990; and*~~

~~(B)the State has submitted enforceable commitments to develop and adopt contingency measures to be implemented as set forth herein if the anticipated technologies do not achieve planned reductions.~~

~~Such contingency measures shall be submitted to the Administrator no later than 3 years before proposed implementation of the plan provisions and approved or disapproved by the Administrator in accordance with section 7410 of this title. The contingency measures shall be adequate to produce emission reductions sufficient, in conjunction with other approved plan provisions, to achieve the periodic emission reductions required by subsection (b)(1) or (c)(2) of this section and attainment by the applicable dates. If the Administrator determines that an Extreme Area has failed to achieve an emission reduction requirement set forth in subsection (b)(1) or (c)(2) of this section, and that such failure is due in whole or part to an inability to fully implement provisions approved pursuant to this subsection, the Administrator shall require the State to implement the contingency measures to the extent necessary to assure compliance with subsections (b)(1) and (c)(2) of this section.~~

~~Any reference to the term "attainment date" in subsection (b), (c), or (d) of this section which is incorporated by reference into this subsection, shall refer to the attainment date for Extreme Areas.~~

3. PROBLEM: The Act as it relates to the demonstration of Reasonable Further Progress or Rate of Progress treats all precursors the same, regardless of their potency in harming public health or achieving attainment. Driven by a rapidly expanding body of scientific research, there is now a growing recognition within the scientific community that from an exposure perspective, the National Ambient Air Quality Standards metrics for progress are a necessary but increasingly insufficient measure of total public health risk associated with air pollutants. In particular, control strategies for sources of PM2.5 and ozone do not necessarily account for qualitative differences in the nature of their emissions. For PM2.5, toxicity has been shown to vary depending on particle size, chemical species, and surface area. In the case of ozone, differences in the relative potency of ozone precursors, VOCs in particular, is not captured by a strict, mass-based approach to precursor controls.

SOLUTION: The Act should be amended to allow states to focus efforts on meeting new standards in the most expeditious fashion through deployment of scarce resources in a manner that provides the utmost benefit to public health. Towards that end, we recommend a more strategic approach in which public health serves as the key factor in prioritizing control measures, regulated pollutants, and sources of emissions. In establishing Reasonable Further Progress or Rate of Progress, the Act should give a greater weight to pollutants that have greater impact on achieving attainment and improving public health. Additionally, in evaluating Reasonably Available Control Technology (RACT), measures that reduce precursors with more impact on ozone formation should be given higher scores than measures that may reduce greater amounts of less potent ozone precursors.

For example, VOC compounds vary significantly in their contribution to the formation of ozone in the San Joaquin Valley. Similarly, NOx emissions reductions have been demonstrated to be approximately 20 times more effective than VOC emissions reductions in reducing the formation of ozone in the San Joaquin Valley. We therefore recommend that in demonstrating Reasonable Further Progress, EPA allow for an alternative approach that can demonstrate equivalent reductions in ozone concentrations as compared to the straight requirement of 3% per year reduction of VOCs and/or NOx.

PROPOSED AMENDMENTS:

Amend Section 182:

(C) NOx control

The revision may contain, in lieu of the demonstration required under subparagraph (B), a demonstration to the satisfaction of the Administrator that the applicable implementation plan, as revised, provides for reductions of emissions of VOC's and oxides of nitrogen (calculated according to the creditability provisions of subsection (b)(1)(C) and (D) of this section), that would result in a reduction in ozone concentrations at least equivalent to that which would result from the amount of VOC emission reductions required under subparagraph (B). Within 1 year after November 15, 1990, the Administrator shall issue guidance concerning the conditions under which NOx control may be substituted for VOC control or may be combined with VOC control in order to maximize the reduction in ozone air pollution. In accord with such guidance, a lesser percentage of VOCs may be accepted as an adequate demonstration for purposes of this subsection. The Administrator shall allow the use of NOx reductions in lieu of VOC reductions. The credit for NOx reductions shall be weighted in proportion to their effectiveness in reducing ozone concentrations in relation to the effectiveness of VOC reductions as demonstrated by the attainment modeling submitted with the plan.

4. PROBLEM: Requiring contingency measures in extreme nonattainment areas is irrational and unnecessary. The Act requires all attainment plans to include contingency measures, defined as extra control measures that go into effect without further regulatory action, if planned emissions controls fail to reach the goals or targets specified in the attainment plan. While requiring backup measures was a well-intentioned provision, it does not make sense in areas that have been classified as "extreme" non-attainment for ozone. These areas, by definition, have already implemented all available and foreseeable measures and still need a "black box" of future measures to define and employ. The term "black box" refers to reductions that are needed to attain the standard, but technology to achieve such reductions does not yet exist. No measures are held in reserve in areas that are classified as "extreme" non-attainment for ozone. With no stones left unturned in such plans, requiring contingency measures in such areas makes no sense.

SOLUTION: We recommend that the Act be amended to eliminate the requirement for contingency measures in areas classified as "extreme" non-attainment by EPA.

PROPOSED AMENDMENTS:

Add to 172(c)(9) as follows:

(9) Contingency measures
Such plan shall provide for the implementation of specific measures to be undertaken if the area fails to make reasonable further progress, or to attain the national primary ambient air quality standard by the attainment date applicable under this part. Such measures shall be included in the plan revision as contingency measures to take effect in any such case without further action by the State or the Administrator. *Notwithstanding this or other sections, contingency measures shall not be required for extreme ozone nonattainment areas.*

5. PROBLEM: The Act requirements for severe and extreme ozone nonattainment areas to address vehicle-related emissions growth must be clarified. Section 182(d)(1)(A) requires such areas to develop enforceable transportation control measures (TCMs) and transportation strategies *"to offset any growth in emissions from growth in vehicle miles traveled ... and to attain reduction in motor vehicle emissions as necessary."* An area's vehicle miles traveled (VMT) may increase due to increases in population (i.e., more drivers), people driving further (i.e., sprawl), or increases in pass-through traffic (i.e., goods movement).

Historically, EPA's section 182(d)(1)(A) approach has allowed the use of vehicle turnover, tailpipe control standards, and the use of alternative fuels to offset the expected increase in VMT. This has allowed for the actual emissions reductions occurring from motor vehicles to be considered in meeting the applicable requirements. A recent Ninth Circuit Court decision, however, has called EPA's current approach for demonstrating the offsetting of vehicle mile-related emissions growth into question, and has forced EPA to reevaluate its approach. Any change in approach that would require regions to offset vehicle growth regardless of population growth, and without recognition of emission reduction measures such as vehicle turnover and tailpipe control standards, would have a significant impact on many regions' ability to develop an approvable attainment strategy and, under a strict interpretation, would actually render attainment impossible. Many TCMs and transportation strategies have already been implemented in nonattainment areas, and remaining opportunities are scarce and extremely expensive to implement, with relatively small amounts of emissions reductions available. A less inclusive section 182(d)(1)(A) approach would effectively penalize nonattainment areas for having population growth, and would not give credit to the significant emissions reductions being achieved from motor vehicles.

To illustrate this issue, such an interpretation applied to the District's 1997 8-hour ozone standard attainment plan would require the elimination of 5.1 million vehicles, while the vehicle population of the Valley is projected to be only 2.6 million vehicles in 2023.

EPA recently established new guidance to address this issue that provides a potential path for reasonably addressing this CAA requirement. However, the path provided under this guidance will undoubtedly be challenged in court as it is utilized by regions like the San Joaquin Valley in the coming years. To provide certainty moving forward, the CAA should be amended to clearly include the methodology for reasonably satisfying this requirement.

SOLUTION: The Act should be amended to allow states to take credit for all transportation control measures and strategies and not punish areas that have implemented transportation control measures and strategies that have achieved early reductions in emissions.

PROPOSED AMENDMENTS:

(1) Vehicle miles traveled
(A) Within 2 years after November 15, 1990, the State shall submit a revision that identifies and adopts specific enforceable transportation control strategies and transportation control measures to offset any growth in emissions from growth in vehicle miles traveled or numbers of vehicle trips in such area and to attain reduction in motor vehicle emissions as necessary, in combination with other emission reduction requirements of this subpart, to comply with the requirements of subsection [5] (b)(2)(B) and (c)(2)(B) of this section (pertaining to periodic emissions reduction requirements). The State shall consider measures specified in section 7408(f) of this title, and choose from among and implement such measures as necessary to demonstrate attainment with the national ambient air quality standards; in considering such measures, the State should ensure adequate access to downtown, other commercial, and residential areas and should avoid measures that increase or relocate emissions and congestion rather than reduce them. As new ozone standards are established, for areas that have implemented early transportation control strategies and transportation control measures, the baseline for demonstrating compliance under this subsection shall remain fixed at 1990 independent of the baseline date for the new plan.

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ISSUE BRIEF

A State-by-State Snapshot of Poverty Among Seniors:

FINDINGS FROM ANALYSIS OF THE SUPPLEMENTAL POVERTY MEASURE

May 2013

Zachary Levinson, Anthony Damico, Juliette Cubanski, and Tricia Neuman

During recent deficit reduction discussions, policymakers have debated whether to increase Medicare beneficiaries' contributions toward their medical care and reduce the cost of living adjustment to Social Security benefits. Having a clear picture of the extent of poverty among seniors, both nationally and at the state level, is important in the context of these debates. Traditionally, the Census Bureau has estimated poverty rates using the "official" poverty measure, which was created in the early 1960s. Some have expressed concern that the official measure is outdated and does not accurately reflect individuals' incomes or financial resources.

In response, the Census Bureau released an alternative measure for the first time in 2011, known as the supplemental poverty measure, which defines income and poverty differently than the official measure. The Census Bureau has reported that poverty rates among the elderly (those ages 65 and older) are higher under the supplemental poverty measure (15%) than under the official poverty measure (9%), which is due in large part to the fact that the former deducts health expenses from income.[1]

This analysis looks beyond the national data to examine results by state. The brief describes the two measures of poverty and examines the share of seniors living in poverty and the share of seniors with modest incomes (defined here as below 200 percent of poverty), by state, under both measures, based on pooled data from the 2009 to 2011 Current Population Surveys.

Key Findings

SENIORS LIVING IN POVERTY, BY STATE:

- The share of seniors living in poverty is higher in every state under the supplemental measure than under the official measure,[2] and at least twice as high in 12 states: California, Colorado, Connecticut, Hawaii, Massachusetts, Maryland, Minnesota, New Hampshire, New Jersey, Nevada, Wisconsin, and Wyoming.

- The share of seniors living in poverty under the supplemental measure is especially high in some areas. Based on the supplemental measure, about one in four seniors (26%) are living in poverty in DC and roughly one in five seniors are living in poverty in six states: California (20%); Hawaii, Louisiana, and Nevada (19%), and Georgia and New York (18%).

Seniors with Incomes Below 200 Percent of Poverty, by State:

- Nationally, nearly half of all seniors (48%) live with incomes below 200 percent of the poverty threshold under the supplemental measure, compared to 34 percent under the official measure.[3] The share of seniors with incomes below 200 percent of poverty is higher under the supplemental measure in every state than under the official measure.[4]
- Under the supplemental measure, at least two-fifths of seniors (40%) have incomes below 200 percent of poverty in 48 states and in DC; using the official measure, this is the case in only six states.
- At least half of seniors have incomes below 200 percent of poverty in 10 states and DC based on the supplemental measure: DC (59%); California (56%); Hawaii (55%); Georgia (54%); Louisiana, New York, Rhode Island, and Tennessee (52%); Florida and Mississippi (51%); and Arizona (50%).

Background

The Census poverty measure is used to provide official statistics of the share of Americans living in poverty.[5] Under this measure, poverty thresholds are set at three times the subsistence food budget from 1963 (adjusted for inflation) and vary based on the size of a family and the age of its members. Among one- and two-person families, thresholds are lower for units with elderly members. For example, in 2011, the poverty threshold (which is different from the "federal poverty level") was $11,702 for an individual under age 65, but $10,788 for an elderly individual.[6,7] When comparing incomes to this threshold, the Census Bureau includes all monetary income (such as income from a job and Social Security benefits) prior to taxes.[8]

The Census Bureau's supplemental poverty measure is based on recommendations of a 1995 National Academy of Sciences Panel and differs from the official measure in several ways, including the following:

- ***Poverty thresholds.*** The supplemental measure bases poverty thresholds on more recent patterns of expenditures on basic necessities (with a small additional allowance) and adjusts them to reflect homeownership status and regional differences in housing prices. For example, under the supplemental measure, the poverty threshold was about $9,500 for a single homeowner without a mortgage living in Charlotte, North Carolina, but was about $16,300 for a homeowner with a mortgage living in San Jose, California. Unlike the official poverty threshold, the supplemental poverty threshold does not differentiate between adults above and below age 65.[9]
- ***Resources.*** When measuring family resources, the supplemental measure adds to monetary income the value of tax credits and in-kind government benefits (such as food stamps) received. It deducts job-related expenses and taxes from income, as well as out-of-pocket expenses on health care.[10] This last deduction is especially important from the perspective of people ages 65 and older, who devote a substantial portion of their incomes to health expenses. In 2009, half of seniors spent at least 16% of their income on health care.[11]

ILLUSTRATIVE EXAMPLES – COMPARING POVERTY UNDER THE OFFICIAL AND SUPPLEMENTAL MEASURES:

John is a 70 year-old man in Louisville, Kentucky who owns a home with a mortgage and lives alone. In 2011, his sole source of income was $17,500 in Social Security benefits. John had a stroke that year, and incurred substantial out-of-pocket health expenses of $8,000 as a result.

- **Under the *official poverty measure*, Doris does NOT fall under the poverty threshold.** In determining John's poverty status, this measure only looks at John's income of $17,500, which is higher than the nationwide official poverty threshold of about $10,800 for an elderly individual who lives alone.
- **Under the *supplemental measure*, however, John IS counted as being in poverty, mainly because of his high medical expenses.** In determining John's poverty status, this measure subtracts the value of his medical expenses ($8,000) from his income of $17,500, leaving resources of $9,500. The supplemental poverty threshold for a homeowner with a mortgage living alone in Louisville is about $10,700.

Doris is an 85 year-old widow who rents an apartment in Miami, Florida. In 2011, her sole source of income was $12,000 in Social Security benefits. She spent $500 on out-of-pocket health care expenses.

- **Under the *official poverty measure*, Doris does NOT fall under the poverty threshold.** In determining her poverty status, this measure only looks at Doris's income of $12,000. This is higher than the nationwide official poverty threshold of about $10,800 for an elderly individual who lives alone.
- **Under the *supplemental measure*, however, Doris IS counted as being in poverty because she lives in an area with a high cost of living.** In determining Doris's poverty status, this measure subtracts her medical expenses of $500 from her income of $12,000, resulting in $11,500 in income. Under the supplemental poverty measure, the threshold for single renters living in Miami is about $13,600. This threshold is higher than under the official measure because the supplemental measure takes local cost-of-living into account, and renters in Doris's area have relatively high living expenses.

Proponents of the supplemental measure argue that it is an improvement upon the official measure because it: provides a more up-to-date standard of the income needed to meet basic needs; adjusts those standards to reflect regional variations in the cost of living; and more accurately conveys the income available to meet those needs by taking into account tax liabilities and credits, in-kind government benefits, and out-of-pocket medical and other expenses.[12]

Others have been critical of the supplemental measure. One criticism is that medical spending is sometimes discretionary, which could imply that the new measure may at times overstate the extent to which medical expenses crowd out spending on basic needs.[13,14] A broader criticism of income-related poverty measures, including both the official and supplemental measures, is that they do not consider the value of families' assets, which could have especially important implications for some seniors.[15] Another limitation of both measures is that they do not consider the risk of facing unaffordable medical expenses in the future, nor the extent to which individuals are insured against those risks.[16]

The poverty rates described in this brief apply to non-institutionalized seniors only, rather than the total Medicare population (which includes younger people with disabilities). The rates presented in this paper are therefore lower than the poverty rates for the Medicare population as a whole because of the exclusion of nonelderly beneficiaries with disabilities (a population with much higher poverty rates than seniors) and the exclusion of seniors residing in facilities, who are more likely to have low incomes than seniors residing in the community.

Findings

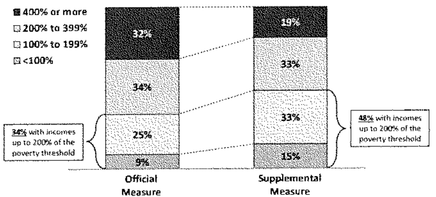
Seniors Living in Poverty Nationwide. The supplemental poverty measure indicates that elderly poverty rates overall and at the state level are much higher than indicated by the official poverty measure. At the national level, this result is largely due to the fact that the supplemental measure deducts health expenses from income, while the official measure does not.[17] Based on pooled data from 2009-2011:[18]

- About one in ten individuals ages 65 and older (9%) have incomes below the poverty level using the official measure, compared to about one in seven (15%) when using the supplemental measure (see Figure 1). The difference between the measures is not as pronounced among non-elderly adults, and poverty rates among children are actually lower under the supplemental measure than they are under the official measure[19] (although poverty rates are higher among children than seniors under both poverty measures, and considerably higher under the official poverty measure).[20]

Figure 1

Percent of People in the U.S. Ages 65 and Older, by Income as a Percent of Poverty, 2009-2011

Comparison of Official Poverty Measure and Supplemental Poverty Measure Estimates



NOTE: Data were pooled over three years.
SOURCE: Current Population Survey, 2009, 2010, and 2011 Annual Social and Economic Supplement.

- The share of elderly people with incomes under 200 percent of poverty is just over a third (34%) under the official measure, but nearly one-half (48%) under the supplemental measure. Conversely, a smaller share of seniors has incomes *above* 400 percent of the poverty threshold under the supplemental measure than under the official measure (19% compared to 32%).

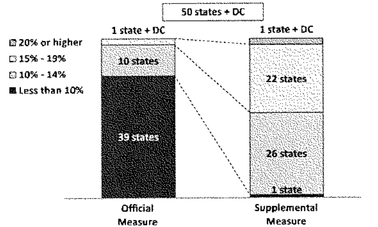
Seniors Living in Poverty, by State. Poverty rates among seniors are higher in every state under the supplemental measure than they are under the official measure:[21]

- Under the supplemental measure, at least 10 percent of seniors live in poverty in nearly every state (all states but Iowa) and in DC; in contrast, under the official measure, senior poverty rates are below 10 percent in most states (39) (see Figure 2 and Appendix Tables 1-3).
- Under the supplemental poverty measure, 15 percent or more of seniors live on incomes below the poverty level in nearly half of the states (23) plus DC, but under the official measure, senior poverty rates are at or above 15 percent only in DC and Louisiana.

Figure 2

Distribution of States by Percent of Residents Ages 65 and Older in Poverty, 2009-2011

Comparison of Official Poverty Measure and Supplemental Poverty Measure Estimates



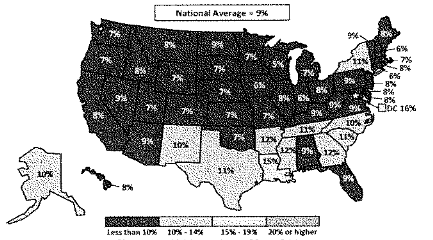
NOTE: Data were pooled over three years.
SOURCE: Current Population Survey, 2009, 2010, and 2011 Annual Social and Economic Supplement.

The share of seniors living in poverty under the supplemental measure is especially high in some states:

- In DC, about one in four seniors (26%) live in poverty under the supplemental measure, compared to 16 percent under the official measure (see Figure 3 and Figure 4).[22]
- In California, one-fifth of seniors (20%) live in poverty under the supplemental measure, compared to 8 percent under the official measure.
- Nearly one in five seniors live in poverty in another five states, including Hawaii, Louisiana, and Nevada (19%) and Georgia and New York (18%).

Figure 3

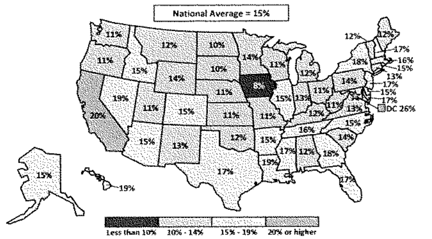
Percent of Individuals Ages 65 and Older With Incomes Below 100% of the Official Poverty Threshold, by State, 2009-2011



NOTE: Data were pooled over three years.
SOURCE: Current Population Survey, 2009, 2010, and 2011 Annual Social and Economic Supplement.

Figure 4

Percent of Individuals Ages 65 and Older With Incomes Below 100% of the Supplemental Poverty Threshold, by State, 2009-2011



NOTE: Data were pooled over three years.
SOURCE: Current Population Survey, 2009, 2010, and 2011 Annual Social and Economic Supplement.

While the share of seniors in poverty is higher under the supplemental measure than the official measure in every state, the difference is especially large in some states. For example:

- In 12 states, poverty rates among seniors are at least twice as high under the supplemental measure as they are under the official measure: California, Colorado, Connecticut, Hawaii, Massachusetts, Maryland, Minnesota, New Hampshire, New Jersey, Nevada, Wisconsin, and Wyoming (see Figure 5).
- In New Hampshire, the share of seniors living in poverty is nearly three times as high (17% under the supplemental measure compared to 6% under the official measure).

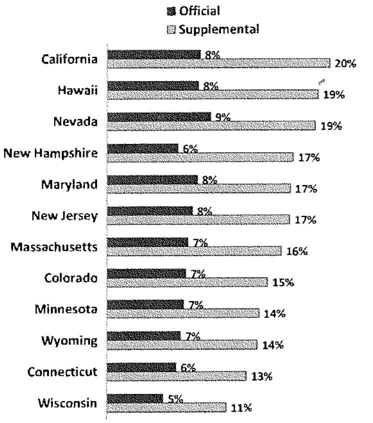
The difference between the official poverty measure and the supplemental poverty measure may vary geographically for several reasons, including state income distributions; differences in housing prices, which are factored into the supplemental poverty thresholds; variations in health utilization and costs, since medical expenses are deducted from income under the supplemental measure but not the official measure; and differences in the generosity of state Medicaid programs, which affects medical expenses.

Seniors with Incomes Below 200 Percent of Poverty, by State. As is the case with poverty rates, the share of seniors with incomes below 200 percent of poverty is higher under the supplemental measure in every state than it is under the official measure, based on pooled data from 2009-2011 (see Appendix Tables 1-3).[23] Under the supplemental measure, at least two-fifths of seniors have incomes below 200 percent of poverty in nearly every state (all but North Dakota and South Dakota) plus DC. In contrast, under the official measure, this is only the case in six states (Arkansas, Georgia, Kentucky, Louisiana, Mississippi, and Tennessee).

Figure 5

Percent of People Ages 65 and Older in Poverty, by State, 2009-2011

States where the poverty rate is at least twice as high under the supplemental measure



NOTE: Data were pooled over three years.
SOURCE: Current Population Survey, 2009, 2010, and 2011 Annual Social and Economic Supplement.

In 10 states and DC, at least half of seniors have incomes below 200 percent of poverty under the supplemental measure. For example:

- In DC, nearly three-fifths of seniors (59%) have incomes below 200 percent of poverty under the supplemental measure, compared to 37 percent under the official measure.
- In California, 56 percent of seniors have incomes below 200 percent of poverty under the supplemental measure, compared to 33 percent under the official measure.
- In Hawaii, 55 percent of seniors have incomes below 200 percent of poverty under the supplemental measure, compared to 30 percent under the official measure.

Although the share of seniors with incomes below 200 percent of poverty is higher in every state under the supplemental measure than under the official measure, the share is much higher in some states. For example:

- The share of seniors with incomes below 200 percent of poverty is at least 20 percentage points higher under the supplemental measure than it is under the official measure in California, Hawaii, and DC.
- This is also true in Maryland, where nearly one-half of seniors (48%) have incomes below 200 percent of poverty under the supplemental measure, compared to just over one-quarter (27%) under the official measure.
- The difference is also greater than 20 percentage points in Connecticut, where 46 percent of seniors have incomes below 200 percent of poverty under the supplemental measure, compared to 26 percent under the official measure.

Discussion

During recent deficit reduction discussions, policymakers have put forth a variety of proposals to reduce Federal spending that would affect people on Medicare, including options that would shift costs onto beneficiaries by increasing the program's cost-sharing requirements or premiums and that would reduce Social Security benefits over time. This analysis provides context for that debate. Based on the Census Bureau's supplemental poverty measure, the poverty rate among people ages 65 and older is higher than is reflected in the official poverty measure, and is particularly high among seniors in some states. With notable differences between the two measures, there is ongoing interest in assessing these methods for measuring poverty and the implications of each measure for public policy.

Under the supplemental poverty measure, which deducts health spending from income, poverty rates could increase if beneficiaries were required to pay higher cost sharing or premiums for Medicare. Medicaid would cover new cost-sharing requirements for some people, but many low-income beneficiaries do not receive Medicaid coverage. Proposed reductions in Social Security benefits, such as imposing a slower rate of growth on benefits by using the chained Consumer Price Index in the cost-of-living update,[24] would be expected to contribute to higher poverty rates among older seniors under both the supplemental and official measure over time. The supplemental measure suggests that a greater share of seniors may already be struggling financially than is conveyed by the official measure.

Methodology

This analysis uses the 2009-2011 Current Population Survey March Annual Social and Economic Supplement (CPS ASEC) for the official poverty figures, as well as the recently-released Supplemental Poverty Measures (SPM) Public Use Research Files – which are derived from the CPS ASEC – for the supplemental poverty figures.[25] Data were pooled across the three years to enable estimates and comparisons at the state level. To achieve consistency across the three years of data, the analysis used the revised 2009 and 2010 SPM files, which are weight-adjusted to the decennial 2010 Census. Standard errors were calculated using the replicate weights and a Fay's adjustment. All reported statistics have a cell size of at least one hundred observations and a relative standard error below 30 percent.

The poverty rates described in this brief may differ from estimates reported elsewhere for a variety of reasons. One reason is because this analysis only includes individuals ages 65 and older. Poverty rates are much higher among non-elderly Medicare beneficiaries with disabilities, which means that poverty rates are higher among the total Medicare population (including both the elderly and non-elderly people with disabilities). The CPS ASEC also does not include seniors residing in institutions, who are more likely to have low incomes than seniors residing in the community. In addition, this analysis compares the incomes of family units to poverty thresholds, consistent with the approach defined by the official and supplemental measures (although each defines families somewhat differently). Relying on a unit of measurement other than family units could produce different poverty rates. For example, health insurance units tend to smaller than family units, and poverty rates may be much higher when based on the former. Finally, the Census Bureau poverty thresholds analyzed in this brief are different than the Health and Human Services (HHS) "poverty guidelines" (also known as the "federal poverty level") used by some programs to determine income eligibility, although the HHS poverty guidelines are a simplified version of the Census poverty thresholds.

The authors gratefully acknowledge feedback on this brief from Dr. Trudi Renwick, Chief of the Poverty Statistics Branch with the Housing and Household Economic Statistics Division of the U.S. Census Bureau

Endnotes

[1] Kathleen Short, "The Research Supplemental Poverty Measure: 2010," *The Census Bureau*, November 2011, http://census.gov/hhes/povmeas/methodology/supplemental/research/Short_ResearchSPM2010.pdf and Kathleen Short, "The Research Supplemental Poverty Measure: 2011," *The Census Bureau*, www.census.gov/prod/2012pubs/p60-244.pdf, November 2012.

[2] The difference was statistically significant in DC and all but 14 states: Alabama, Arkansas, Iowa, Kansas, Kentucky, Louisiana, Missouri, North Dakota, New Mexico, South Carolina, South Dakota, Utah, Vermont, and West Virginia.

[3] The share of Medicare beneficiaries overall with incomes below 100 percent and 200 percent of the poverty thresholds is higher than for seniors, because poverty rates are higher among disabled Medicare beneficiaries than among seniors.

[4] The difference was statistically significant in DC and all but 9 states: Alabama, Arkansas, Iowa, Kentucky, Louisiana, Montana, North Dakota, Oklahoma, and West Virginia.

[5] "Frequently Asked Questions Related to the Poverty Guidelines and Poverty," Health and Human Services Assistant Secretary of Planning and Evaluation, accessed on May 8, 2013, http://aspe.hhs.gov/poverty/faq.cfm.

[6] The "federal poverty level" is a simplified version of the poverty threshold that is used in some instances to determine eligibility for public assistance.

[7] "Poverty Thresholds for 2012 by Size of Family and Number of Related Children Under 18 Years," The Census Bureau, http://census.gov/hhes/www/poverty/data/threshld/index.html.

[8] Short, "The Research Supplemental Poverty Measure: 2011."

[9] Short, "The Research Supplemental Poverty Measure: 2011."

[10] Short, "The Research Supplemental Poverty Measure: 2011."

[11] Kaiser Family Foundation analysis of the CMS Medicare Current Beneficiary Survey 2009 Cost and Use File.

[12] Rebecca M. Blank and Mark E. Greenberg, "Improving the Measurement of Poverty", *The Brookings Institution*. December 2008, www.brookings.edu/research/papers/2008/12/poverty-measurement-blank.

[13] John F. Cogan, "Measuring Poverty: A New Approach – Appendix A: Dissent," *National Academy of Sciences*, 1995, http://nap.edu/openbook.php?record_id=4759&page=385 and Bruce D. Meyer and James X. Sullivan., "Identifying the Disadvantaged: Official Poverty, Consumption Poverty, and the New Supplemental Poverty Measure", *Journal of Economic Perspectives* 26, no.3 (2012), http://aeaweb.org/articles.php?doi=10.1257/jep.26.3.111.

[14] Analysts have also debated how to update the measure over time, although that discussion is less relevant to this brief, which provides a snapshot of poverty. According to the Census Bureau, the official and supplemental poverty rates among the overall population differed by one percentage point or less from 2009 – 2011. Over time, official poverty thresholds will change with inflation, effectively maintaining their real value, while the supplemental thresholds will increase based on the 33rd percentile of expenditures on basic necessities (multiplied by 1.2). Because the latter is based on actual spending patterns, supplemental poverty thresholds may increase over time with improvements in the general standard of living, a feature that is debated among policy analysts (see for example Robert Rector and Rachel Sheffield, "Obama's New Poverty Measure 'Spreads the Wealth'," *National Review*, November, 9, 2011, http://heritage.org/research/commentary/2011/11/obamas-new-poverty-measure-spreads-the-wealth and Blank and Greenberg, "Improving the Measurement of Poverty").

[15] Meyer and Sullivan, "Identifying the Disadvantaged: Official Poverty, Consumption Poverty, and the New Supplemental Poverty Measure."

[16] The authors of the NAS report recommended developing a separate measure for such "medical care risk." Robert T. Michael et al., "Measuring Poverty: A New Approach", *National Academy of Sciences*, 1995, http://nap.edu/openbook.php?isbn=0309051282.

[17] Based on 2009, 2010, and 2011 results from the Census Bureau, the national poverty rate for individuals ages 65 and older would not differ substantially under the supplemental and official measures if the former did not exclude medical expenses (Short, "The Research Supplemental Poverty Measure: 2011" and Short, "The Research Supplemental Poverty Measure: 2010"). The Census Bureau also notes that elderly poverty rates under the official and supplemental measures differ partially because the official poverty threshold is lower for families with seniors in some instances, while the supplemental poverty threshold does not differentiate between adults above and below age 65.

[18] This is very similar to analysis conducted in Short, "The Research Supplemental Poverty Measure: 2011" and Short, "The Research Supplemental Poverty Measure: 2010." However, this output includes pooled data from 2009-2011 to match the state-level analysis in this brief.

[19] This is in part because of the inclusion of refundable tax credits and food stamps. Carmen DeNavas-Walt, Bernadette D. Proctor, and Jessica C. Smith, "Income, Poverty, and Health Insurance Coverage in the United States: 2009," September 2010, http://census.gov/prod/2010pubs/p60-238.pdf; Short, "The Research Supplemental Poverty Measure: 2011;" and Short, "The Research Supplemental Poverty Measure: 2010."

[20] Poverty rates are higher among nonelderly Medicare beneficiaries with disabilities than among seniors under both the official measure (27% compared to 9%) and the supplemental measure (25% compared to 15%). Unlike poverty rates among seniors, poverty rates among nonelderly Medicare beneficiaries with disabilities are *lower* under the supplemental measure than they are under the official measure. This might in part reflect the comparatively high rates of Medicaid coverage and receipt of other federal assistance payments such as food stamps among nonelderly Medicare beneficiaries with disabilities relative to seniors.

[21] The difference was statistically significant in DC and all but 14 states: Alabama, Arkansas, Iowa, Kansas, Kentucky, Louisiana, Missouri, North Dakota, New Mexico, South Carolina, South Dakota, Utah, Vermont, and West Virginia.

[22] We did not assess whether the poverty rate among seniors in DC is also high relative to other major metropolitan areas, due to limitations with the Current Population Survey (CPS) city data. CPS also includes data on "core based statistical areas" (CBSAs), which include a county containing at least one urban area of 10,000 people or more and related regions nearby. The CBSA containing DC also includes other areas in Maryland, Virginia, and West Virginia, and has a lower senior poverty rate under the supplemental measure relative to DC alone (18% compared to 26%). Of the 30 largest CBSAs, the CBSA containing DC had the 12th highest supplemental poverty rate among seniors, while the CBSAs containing San Jose, Los Angeles, and Miami had the highest poverty rates (26%, 25%, and 24% respectively).

[23] The difference was statistically significant in DC and all but 9 states: Alabama, Arkansas, Iowa, Kentucky, Louisiana, Montana, North Dakota, Oklahoma, and West Virginia.

[24] Social Security benefits are currently adjusted based on the consumer price index (specifically, the CPI-W) to reflect increases in the cost of living. Some deficit recommendation proposals – including the proposals put forth by The National Commission on Fiscal Responsibility and Reform (sometimes referred to as "Simpson-Bowles") and The Debt Reduction Task Force (sometimes referred to as "Domenici-Rivlin") – have suggested updating Social Security benefits based on another version of inflation, known as the "chained" CPI. Because this measure tends to increase less quickly than the CPI-W, Social Security benefits would likely decline over time.

[25] Available at: www.census.gov/hhes/povmeas/data/supplemental/public-use.html.

APPENDIX TABLE 1: PERCENT OF INDIVIDUALS AGES 65 AND OLDER WITH INCOMES BELOW 100% AND 200% OF POVERTY, 2009-2011

	BELOW 100% OF THE POVERTY THRESHOLD			BELOW 200% OF THE POVERTY THRESHOLD		
STATE	OFFICIAL POVERTY MEASURE	SUPPLEMENTAL POVERTY MEASURE	PERCENTAGE POINT DIFFERENCE	OFFICIAL POVERTY MEASURE	SUPPLEMENTAL POVERTY MEASURE	PERCENTAGE POINT DIFFERENCE
UNITED STATES	9%	15%	6%*	34%	48%	14%*
Alaska	10%	15%	5%*	31%	47%	16%*
Alabama	9%	12%	3%	39%	45%	6%
Arkansas	12%	15%	3%	44%	50%	7%
Arizona	9%	15%	6%*	31%	42%	12%*
California	8%	20%	12%*	33%	56%	23%*
Colorado	7%	15%	8%*	28%	42%	15%*
Connecticut	6%	13%	6%*	26%	46%	20%*
DC	16%	26%	10%*	37%	59%	22%*
Delaware	8%	15%	7%*	29%	46%	17%*
Florida	9%	17%	9%*	33%	51%	18%*
Georgia	12%	18%	6%*	42%	54%	11%*
Hawaii	8%	19%	11%*	30%	55%	25%*
Iowa	6%	8%	2%	33%	41%	8%
Idaho	8%	15%	6%*	32%	43%	11%*
Illinois	8%	15%	7%*	34%	47%	13%*
Indiana	8%	13%	5%*	34%	48%	14%*
Kansas	7%	11%	4%	32%	41%	9%*
Kentucky	9%	12%	3%	41%	48%	7%
Louisiana	15%	19%	4%	45%	52%	6%
Massachusetts	7%	16%	9%*	30%	48%	18%*
Maryland	8%	17%	9%*	27%	48%	21%*
Maine	8%	12%	4%*	36%	47%	12%*
Michigan	7%	12%	4%*	32%	44%	13%*
Minnesota	7%	14%	7%*	31%	44%	13%*
Missouri	7%	11%	4%	35%	43%	8%*
Mississippi	12%	17%	5%*	43%	51%	8%*
Montana	8%	12%	4%*	39%	45%	6%
North Carolina	10%	15%	5%*	39%	47%	8%*
North Dakota	9%	10%	1%	30%	36%	6%
Nebraska	7%	11%	5%*	30%	40%	11%*
New Hampshire	6%	17%	11%*	30%	49%	19%*
New Jersey	8%	17%	9%*	30%	49%	19%*
New Mexico	10%	13%	2%	36%	45%	9%*
Nevada	9%	19%	10%*	30%	49%	19%*
New York	11%	18%	7%*	35%	52%	17%*
Ohio	8%	11%	3%*	35%	44%	9%*
Oklahoma	7%	12%	5%*	34%	41%	7%
Oregon	7%	11%	4%*	28%	43%	15%*
Pennsylvania	9%	14%	5%*	35%	46%	12%*
Rhode Island	8%	15%	6%*	36%	52%	16%*
South Carolina	11%	14%	3%	38%	47%	9%*
South Dakota	7%	10%	3%	29%	37%	8%*
Tennessee	11%	16%	5%*	42%	52%	10%*
Texas	11%	17%	6%*	36%	47%	11%*
Utah	7%	11%	4%	28%	43%	15%*
Virginia	9%	13%	4%*	29%	42%	13%*
Vermont	9%	12%	3%	35%	47%	12%*
Washington	7%	11%	5%*	25%	42%	16%*
Wisconsin	5%	11%	6%*	30%	40%	11%*
West Virginia	9%	11%	2%	38%	43%	5%
Wyoming	7%	14%	7%*	33%	46%	13%*

Notes: Data were pooled over three years. * Indicates statistical significance at the 95 percent confidence level.
Source: Current Population Survey, 2009, 2010, and 2011 Annual Social and Economic Supplement.

APPENDIX TABLE 2: PERCENT OF INDIVIDUALS AGES 65 AND OLDER WITH INCOMES BELOW 100% AND 200% OF POVERTY, 2009-2011, SORTED BY POVERTY RATES BASED ON THE SUPPLEMENTAL MEASURE

	BELOW 100% OF THE POVERTY THRESHOLD			BELOW 200% OF THE POVERTY THRESHOLD		
STATE	OFFICIAL POVERTY MEASURE	SUPPLEMENTAL POVERTY MEASURE	PERCENTAGE POINT DIFFERENCE	OFFICIAL POVERTY MEASURE	SUPPLEMENTAL POVERTY MEASURE	PERCENTAGE POINT DIFFERENCE
UNITED STATES	9%	15%	6%*	34%	48%	14%*
District of Columbia	16%	26%	10%*	37%	59%	22%*
California	8%	20%	12%*	33%	56%	23%*
Hawaii	8%	19%	11%*	30%	55%	25%*
Nevada	9%	19%	10%*	30%	49%	19%*
Louisiana	15%	19%	4%	45%	52%	6%
New York	11%	18%	7%*	35%	52%	17%*
Georgia	12%	18%	6%*	42%	54%	11%*
Florida	9%	17%	9%*	33%	51%	18%*
Mississippi	12%	17%	5%*	43%	51%	8%*
New Hampshire	6%	17%	11%*	30%	49%	19%*
Maryland	8%	17%	9%*	27%	48%	21%*
New Jersey	8%	17%	9%*	30%	49%	19%*
Texas	11%	17%	6%*	36%	47%	11%*
Tennessee	11%	16%	5%*	42%	52%	10%*
Massachusetts	7%	16%	9%*	30%	48%	18%*
Alaska	10%	15%	5%*	31%	47%	16%*
Arkansas	12%	15%	3%	44%	50%	7%
North Carolina	10%	15%	5%*	39%	47%	8%*
Arizona	9%	15%	6%*	31%	42%	12%*
Delaware	8%	15%	7%*	29%	46%	17%*
Colorado	7%	15%	8%*	28%	42%	15%*
Illinois	8%	15%	7%*	34%	47%	13%*
Rhode Island	8%	15%	6%*	36%	52%	16%*
Idaho	8%	15%	6%*	32%	43%	11%*
South Carolina	11%	14%	3%	38%	47%	9%*
Minnesota	7%	14%	7%*	31%	44%	13%*
Pennsylvania	9%	14%	5%*	35%	46%	12%*
Wyoming	7%	14%	7%*	33%	46%	13%*
Indiana	8%	13%	5%*	34%	48%	14%*
Virginia	9%	13%	4%*	29%	42%	13%*
Connecticut	6%	13%	6%*	26%	46%	20%*
New Mexico	10%	13%	2%	36%	45%	9%*
Alabama	9%	12%	3%	39%	45%	6%
Maine	8%	12%	4%*	36%	47%	12%*
Montana	8%	12%	4%*	39%	45%	6%
Oklahoma	7%	12%	5%*	34%	41%	7%
Kentucky	9%	12%	3%	41%	48%	7%
Michigan	7%	12%	4%*	32%	44%	13%*
Vermont	9%	12%	3%	35%	47%	12%*
Oregon	7%	11%	4%*	28%	43%	15%*
Washington	7%	11%	5%*	25%	42%	16%*
Missouri	7%	11%	4%	35%	43%	8%*
Nebraska	7%	11%	5%*	30%	40%	11%*
West Virginia	9%	11%	2%	38%	43%	5%
Utah	7%	11%	4%	28%	43%	15%*
Ohio	8%	11%	3%*	35%	44%	9%*
Wisconsin	5%	11%	6%*	30%	40%	11%*
Kansas	7%	11%	4%	32%	41%	9%*
North Dakota	9%	10%	1%	30%	36%	6%
South Dakota	7%	10%	3%	29%	37%	8%*
Iowa	6%	8%	2%	33%	41%	8%

Notes: Data were pooled over three years. * Indicates statistical significance at the 95 percent confidence level.
Source: Current Population Survey, 2009, 2010, and 2011 Annual Social and Economic Supplement.

APPENDIX TABLE 3: PERCENT OF INDIVIDUALS AGES 65 AND OLDER WITH INCOMES BELOW 100% AND 200% OF POVERTY, 2009-2011, SORTED BY THE DIFFERENCE BETWEEN THE OFFICIAL AND SUPPLEMENTAL POVERTY RATES

	BELOW 100% OF THE POVERTY THRESHOLD			BELOW 200% OF THE POVERTY THRESHOLD		
STATE	OFFICIAL POVERTY MEASURE	SUPPLEMENTAL POVERTY MEASURE	PERCENTAGE POINT DIFFERENCE	OFFICIAL POVERTY MEASURE	SUPPLEMENTAL POVERTY MEASURE	PERCENTAGE POINT DIFFERENCE
UNITED STATES	9%	15%	6%*	34%	48%	14%*
California	8%	20%	12%*	33%	56%	23%*
Hawaii	8%	19%	11%*	30%	55%	25%*
New Hampshire	6%	17%	11%*	30%	49%	19%*
District of Columbia	16%	26%	10%*	37%	59%	22%*
Nevada	9%	19%	10%*	30%	49%	19%*
New Jersey	8%	17%	9%*	30%	49%	19%*
Massachusetts	7%	16%	9%*	30%	48%	18%*
Maryland	8%	17%	9%*	27%	48%	21%*
Florida	9%	17%	9%*	33%	51%	18%*
Colorado	7%	15%	8%*	28%	42%	15%*
New York	11%	18%	7%*	35%	52%	17%*
Delaware	8%	15%	7%*	29%	46%	17%*
Wyoming	7%	14%	7%*	33%	46%	13%*
Illinois	8%	15%	7%*	34%	47%	13%*
Minnesota	7%	14%	7%*	31%	44%	13%*
Connecticut	6%	13%	6%*	26%	46%	20%*
Rhode Island	8%	15%	6%*	36%	52%	16%*
Georgia	12%	18%	6%*	42%	54%	11%*
Idaho	8%	15%	6%*	32%	43%	11%*
Arizona	9%	15%	6%*	31%	42%	12%*
Texas	11%	17%	6%*	36%	47%	11%*
Wisconsin	5%	11%	6%*	30%	40%	11%*
Indiana	8%	13%	5%*	34%	48%	14%*
Alaska	10%	15%	5%*	31%	47%	16%*
North Carolina	10%	15%	5%*	39%	47%	8%*
Pennsylvania	9%	14%	5%*	35%	46%	12%*
Oklahoma	7%	12%	5%*	34%	41%	7%
Tennessee	11%	16%	5%*	42%	52%	10%*
Washington	7%	11%	5%*	25%	42%	16%*
Mississippi	12%	17%	5%*	43%	51%	8%*
Nebraska	7%	11%	5%*	30%	40%	11%*
Michigan	7%	12%	4%*	32%	44%	13%*
Oregon	7%	11%	4%*	28%	43%	15%*
Missouri	7%	11%	4%	35%	43%	8%*
Maine	8%	12%	4%*	36%	47%	12%*
Montana	8%	12%	4%*	39%	45%	6%
Louisiana	15%	19%	4%	45%	52%	6%
Kansas	7%	11%	4%	32%	41%	9%*
Utah	7%	11%	4%	28%	43%	15%*
Virginia	9%	13%	4%*	29%	42%	13%*
Alabama	9%	12%	3%	39%	45%	6%
Vermont	9%	12%	3%	35%	47%	12%*
Arkansas	12%	15%	3%	44%	50%	7%
South Carolina	11%	14%	3%	38%	47%	9%*
Ohio	8%	11%	3%*	35%	44%	9%*
Kentucky	9%	12%	3%	41%	48%	7%
South Dakota	7%	10%	3%	29%	37%	8%*
New Mexico	10%	13%	2%	36%	45%	9%*
Iowa	6%	8%	2%	33%	41%	8%
West Virginia	9%	11%	2%	38%	43%	5%
North Dakota	9%	10%	1%	30%	36%	6%

Notes: Data were pooled over three years. * Indicates statistical significance at the 95 percent confidence level.
Source: Current Population Survey, 2009, 2010, and 2011 Annual Social and Economic Supplement.

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THE HENRY J. KAISER FAMILY FOUNDATION

Headquarters
2400 Sand Hill Road
Menlo Park, CA 94025
Phone 650-854-9400 Fax 650-854-4800

Washington Offices and
Barbara Jordan Conference Center
1330 G Street, NW
Washington, DC 20005
Phone 202-347-5270 Fax 202-347-5274

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Baton Rouge Area Chamber®

Leading Economic Development
in the Baton Rouge Area

BRAC Public Policy Commentary:
Eighteen of Twenty Top-Performing Metro Economies at Risk from New Ozone Standards

Published on Monday, March 2, 2015

All but two of the nation's top twenty metropolitan area economies, as ranked by the Brookings Institution's assessment of performance through recession and recovery, would fall into "ozone nonattainment" status if the Obama administration moves forward with its more aggressive regulatory plans for air quality, according to an analysis completed by the Baton Rouge Area Chamber (BRAC)

The proposed National Ambient Air Quality Standards (NAAQS) for ground level ozone rule, issued by the Environmental Protection Agency (EPA) on December 17, 2014, is designed to lower the current NAAQS of seventy-five parts-per-billion (ppb) to a range between sixty-five and seventy ppb. Should the Obama administration push forward with a standard of sixty-five ppb, eighteen of the U.S.'s twenty top-performing metropolitan economies would find themselves in a regulatory posture of "nonattainment," and all the regulatory consequences that entails.

Brookings Institute Metro Monitor - September 2014

City/Area	State	Overall Rank (Recession + Recovery)	Ozone Design Value 2011-2013
Austin	Texas	1	73
Harris/ Houston	Texas	2	82
San Antonio/Bexar	Texas	3	81
Dallas	Texas	4	84
Oklahoma County	Oklahoma	5	79
Davidson/Nashville	Tennessee	6	70
Provo/Orem	Utah	7	73
San Jose/Silicon Valley (Santa Clara)	California	8	68
Delaware/Columbus	Ohio	9	80
El Paso	Texas	10	72
Denver/Boulder	Colorado	11	79
Portland	Oregon	12	56
Salt Lake	Utah	13	76
Raleigh/Durham	North Carolina	14	71
Omaha	Nebraska	15	67
Charleston	South Carolina	16	63
Pittsburgh	Pennsylvania	17	76
Spartanburg/Greenville	South Carolina	18	72
Grand Rapids	Michigan	19	74
Baton Rouge	**Louisiana**	**20**	**75**

Brookings' Metro Monitor tracks the performance of the one hundred largest U.S. metropolitan areas on four indicators: jobs, unemployment, output (gross product), and house prices. The analysis of these indicators is focused on change during three time periods: the recession, the recovery, and the combination of the two (recession + recovery).

Using the rankings from the Brookings combination assessment (recession + recovery), BRAC then cross-matched those metropolitan areas with their respective ozone design values (average of fourth highest readings over a period of three years), as compiled by the EPA. For instance, the Baton Rouge Area ranks as the twentieth best-performing metropolitan economy in the U.S., with an ozone design value of seventy-five ppb (parts per billion).*

It should also be noted that, while this analysis makes use of the design value computed for the three-year period covering 2011 through 2013, the Baton Rouge Area was determined to meet the current standard (seventy-five ppb) in 2013 and again in 2014, and has continued to measure below seventy-five ppb throughout its statistical area. **Yet while the Baton Rouge Area continues to make this positive environmental progress, it also has firsthand experience with what it means to be in nonattainment – a status that could soon apply to almost all other top-performing metros.**

A report published by the National Association of Manufacturers in July 2014 assessed the potential economic impact of the proposed new ozone standards, but it also touched upon what "nonattainment" means in practical terms. As the report explained:

> "The greatest costs to comply with ozone regulations generally occur in nonattainment areas. The consequences for nonattainment are severe and can include a loss of industry and economic development resulting from increased costs, delays and uncertainties from restrictive permitting requirements; loss of federal highway and transit funding; requirements that any new emissions in the area be offset or the facility cannot be built; and technical and formula changes for commercial and consumer products."

Mary Martin, who serves as Energy, Clean Air and Natural Resources Policy counsel for the U.S. Chamber, has described how these restrictions translate into consequences:

> "[F]ailure to comply with existing ozone standards can lead to non-attainment designation, which are often viewed as a death knell for economic and business development in an area.
>
> "Indeed, severe repercussion[s] result almost immediately from non-attainment designation, such as increased costs to industry, permitting delays, restrictions on expansion, as well as impacts to transportation planning. There are significant adverse consequences to being designated a non-attainment area, making it substantially harder for a community to attract new business or expand existing facilities. Furthermore, in non-attainment areas, EPA is able to revise existing air permits, which can cause tremendous uncertainty, delays, and increased costs in the permitting process for businesses."

While the Baton Rouge Area Chamber believes in and stands for cleaner air and an improved environment, it continues to vehemently oppose the proposed reductions in ambient air quality standards from the current level of seventy-five ppb.

Since the EPA first proposed lowering the ozone standard in December, the Baton Rouge Area has seen four major industrial projects totaling 2,000 direct and indirect jobs, and more than $7 billion in capital investment, either put on hold or redirected elsewhere. These losses are in direct correlation with the uncertainty created by the newly proposed ozone standards rule. The direct impact on the Baton Rouge Area, in terms of new payroll created from the projects themselves, would have been over $86 million annually in wages for the local economy. Also, because these projects included foreign direct investment projects, they also represented new investment from multi-national corporations into the country. **Federal regulations concerning NAAQS are having a direct, negative effect on competing U.S. goals for increasing foreign direct investment and exports.**

In the Baton Rouge Area case outlined above, these consequences came about merely from the regulation being *proposed*. Imagine the losses if it is actually implemented, losses not only for Baton Rouge but for other top-performing metros across the country. The implication is that U.S. government policy toward ozone, as proposed, runs in direct contradiction to America's economic goals. More time should be taken to plan solutions that avoid the negative effects on the national economy, and especially on the top-performing regional economies in the United States.

**EPA recommends using the Core Based Statistical Area (CBSA) as the starting point to determine boundaries of ozone nonattainment. Based on this approach the highest monitored value of ozone in a CBSA was provided.*

About the Baton Rouge Area Chamber
The Baton Rouge Area Chamber (BRAC) leads economic development in the nine-parish Baton Rouge Area, working to attract new companies and assisting existing companies with growth and expansions. Today, BRAC investors include more than 1,300 businesses, civic organizations, education institutions, and individuals. In this capacity, BRAC serves as the voice of the business community, providing knowledge, access, services, and advocacy. More information is available at www.brac.org.

For more information, contact:

Lauren Hatcher
Director, Marketing Operations
Baton Rouge Area Chamber
225-381-7132
lauren@brac.org

STATE OF GEORGIA
OFFICE OF THE GOVERNOR
ATLANTA 30334-0090

Nathan Deal
GOVERNOR

February 20th, 2015

The Honorable Gina McCarthy
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Ave N.W.
Washington, D.C. 20460

Dear Administrator McCarthy,

In the four decades since the Clean Air Act was signed into law, the State of Georgia has achieved unprecedented improvements to the quality of the air we breathe. We have done so while adhering to the core principle that protection of the environment must be balanced with economic progress. It is for this reason that I, in my role as guardian of our state's quality of life, oppose changing the National Ambient Air Quality Standard (NAAQS) for ground-level ozone at this time.

Your agency is contemplating a NAAQS so stringent that even some of our country's pristine national parks may not be able to satisfy it. Many areas in Georgia have background levels of ozone at or near the levels under consideration, making it almost impossible for these cities and counties to come into compliance. If they cannot, new business development will be constrained as these counties are placed in nonattainment status, an economic penalty box that makes it so hard to build something new that many companies simply build elsewhere. Existing businesses in Georgia would also be impacted, as additional unknown control measures will likely be required to achieve a more stringent standard. In the end, Georgia citizens will have less money to spend on food, clothing and other basic needs because they will be spending this money instead on the new costs that have been passed through to them from ozone regulations. This all adds up to what many are calling the "most expensive regulation ever."

My state is already in the process of planning for and implementing dozens of massive new regulations put in place by your agency over the past several years, regulations like the Mercury and Air Toxics Standards, the Boiler MACT, regional haze rules, the Cross-State Air Pollution Rule, and most recently the Clean Power Plan. Very notably, states have only begun to implement the ozone NAAQS put in place in 2008, a standard for which implementation guidance was only just issued by EPA this month. These rules are in addition to fuel economy standards and Tier 3 tailpipe emission standards for cars and trucks implemented at the federal level which increase costs for businesses and consumers in my state and others. All of these regulations have required substantial investments on the part of Georgia companies and consumers and constitute a moving target for Georgia companies. I urge you to defer setting a more stringent ozone standard to allow these existing regulations to have an impact and to avoid the costly planning and economic burden of additional regulation.

The currently proposed revision to the ozone NAAQS may be the most expensive regulation in our nation's history. It is my duty to my constituents to urge you to set an ozone standard that does not place this undue burden on states. We ask you to keep the current standard of 75 parts per billion (ppb) in place.

Sincerely,

Nathan Deal

Nathan Deal

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Association of Improved Air Quality with Lung Development in Children

W. James Gauderman, Ph.D., Robert Urman, M.S., Edward Avol, M.S., Kiros Berhane, Ph.D., Rob McConnell, M.D., Edward Rappaport, M.S., Roger Chang, Ph.D., Fred Lurmann, M.S., and Frank Gilliland, M.D., Ph.D.

ABSTRACT

BACKGROUND

Air-pollution levels have been trending downward progressively over the past several decades in southern California, as a result of the implementation of air quality–control policies. We assessed whether long-term reductions in pollution were associated with improvements in respiratory health among children.

METHODS

As part of the Children's Health Study, we measured lung function annually in 2120 children from three separate cohorts corresponding to three separate calendar periods: 1994–1998, 1997–2001, and 2007–2011. Mean ages of the children within each cohort were 11 years at the beginning of the period and 15 years at the end. Linear-regression models were used to examine the relationship between declining pollution levels over time and lung-function development from 11 to 15 years of age, measured as the increases in forced expiratory volume in 1 second (FEV$_1$) and forced vital capacity (FVC) during that period (referred to as 4-year growth in FEV$_1$ and FVC).

RESULTS

Over the 13 years spanned by the three cohorts, improvements in 4-year growth of both FEV$_1$ and FVC were associated with declining levels of nitrogen dioxide ($P<0.001$ for FEV$_1$ and FVC) and of particulate matter with an aerodynamic diameter of less than 2.5 μm ($P=0.008$ for FEV$_1$ and $P<0.001$ for FVC) and less than 10 μm ($P<0.001$ for FEV$_1$ and FVC). These associations persisted after adjustment for several potential confounders. Significant improvements in lung-function development were observed in both boys and girls and in children with asthma and children without asthma. The proportions of children with clinically low FEV$_1$ (defined as <80% of the predicted value) at 15 years of age declined significantly, from 7.9% to 6.3% to 3.6% across the three periods, as the air quality improved ($P=0.001$).

CONCLUSIONS

We found that long-term improvements in air quality were associated with statistically and clinically significant positive effects on lung-function growth in children. (Funded by the Health Effects Institute and others.)

From the Department of Preventive Medicine, University of Southern California, Los Angeles (W.J.G., R.U., E.A., K.B., R.M., E.R., R.C., F.G.) and Sonoma Technologies, Petaluma (F.L.) — both in California. Address reprint requests to Dr. Gauderman at the Department of Preventive Medicine, University of Southern California, 2001 Soto St., 202-K, Los Angeles, CA 90032, or at jimg@usc.edu.

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IN PREVIOUS INVESTIGATIONS, WE AND OTHERS have linked exposure to ambient air pollution with lung-function impairment in children.[1-8] Reduced lung function in children has been associated with an increased risk of asthma.[9] In addition, the adverse effects of air pollution on the lungs in childhood can potentially have long-term effects: lung function lower than the predicted value for a healthy adult has been found to be associated with an increased risk of cardiovascular disease and increased mortality rate.[10-12] Although progress has been made throughout the United States to reduce outdoor levels of several air pollutants, it is not known whether these reductions have been associated with improvements in children's respiratory health.

A Quick Take summary is available at NEJM.org

Southern California has historically been plagued by high levels of air pollution owing to the presence of a large motor-vehicle fleet, numerous industries, the largest seaport complex in the United States, and a natural landscape that traps polluted air over the Los Angeles basin. With mounting scientific evidence of the adverse health effects of air pollution, aggressive pollution-reduction policies have been enacted. These have included strategies to control pollution from mobile and stationary sources, as well as fuel and consumer-product reformulations. As a result, air-pollution levels have been trending downward over the past several decades in southern California.

Improvements in air quality over time provide the backdrop for a "natural experiment" to examine the potential beneficial health effects. As part of the 20-year Children's Health Study, three separate cohorts of children have had longitudinal lung-function measurements recorded over the same 4-year age range (11 to 15 years) and in the same five study communities but during different calendar periods. In this study, we examined whether changes that have occurred across these time spans in levels of nitrogen dioxide, ozone, and particulate matter with an aerodynamic diameter of less than 2.5 μm ($PM_{2.5}$), less than 10 μm (PM_{10}), and between 2.5 and 10 μm (coarse particulate matter [PM_{10}–$PM_{2.5}$]) are associated with the development of lung function in children.

METHODS

PARTICIPANTS

The study sample included children recruited from three separate Children's Health Study cohorts (Fig. S1 in the Supplementary Appendix, available with the full text of this article at NEJM.org). The two earlier cohorts (cohorts C and D) enrolled fourth-grade students in 1992–1993 and 1995–1996, respectively, from elementary schools in 12 southern California communities.[13] The third cohort (cohort E) enrolled kindergarten and first-grade students in 2002–2003 from 13 communities,[14] 9 of which overlapped with the 12 cohort C and D communities. Because of budgetary limitations, pulmonary-function testing was conducted in only 5 of the 9 overlapping communities. To facilitate direct comparisons across calendar periods, analyses were restricted to the 5 study communities (Long Beach, Mira Loma, Riverside, San Dimas, and Upland) in which pulmonary-function testing was performed in all three cohorts (Fig. S2 in the Supplementary Appendix). This sample included a total of 2120 children, including 669 in cohort C, 588 in cohort D, and 863 in cohort E.

The study protocol was approved by the institutional review board for human studies at the University of Southern California, and written informed consent was provided by a parent or legal guardian for all study participants.

PULMONARY-FUNCTION TESTING

Trained technicians assisted the students in performing pulmonary-function maneuvers that met the standards of the American Thoracic Society, as described elsewhere.[8] For each child, maximal forced expiratory volume in 1 second (FEV_1) and forced vital capacity (FVC) were measured. For cohorts C and D, pulmonary-function testing was performed annually from 4th through 12th grade (mean ages, 10 to 18 years), with the use of rolling-seal spirometers. In cohort E, pulmonary-function testing was performed every other year, when the children were approximately 11, 13, and 15 years of age, with the use of pressure transducer–based spirometers. Of the 2120 children, 1585 (74.8%) were tested at the beginning (age 11 years) and end (age 15 years) of the follow-up period, whereas the remaining 535 children (25.2%) were tested at 11 but not at 15 years of age.

QUESTIONNAIRES

Written questionnaires regarding each child's general health and personal exposures were completed by the parent or guardian at baseline and by the

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child participants annually throughout the study thereafter. The questionnaires obtained basic information about the child, including age, sex, self-identified race and ethnic background, insurance coverage, and parental education, as well as the child's health conditions (asthma or acute respiratory illness), tobacco-smoke exposures (personal smoking, secondhand exposure, or in utero exposure), and other exposures.

AIR POLLUTANTS

Outdoor air-pollution monitoring stations in each of the study communities have been continuously measuring regional air pollutants since 1994. Data on hourly or daily concentrations of nitrogen dioxide, $PM_{2.5}$, PM_{10}, and ozone were routinely collected with Federal Reference Method or Federal Equivalent Method instrumentation. A systematic quality-assurance program was in place to review all data. Mean air-pollutant concentrations were calculated for each community over the relevant periods of exposure for each cohort (1994–1997 for cohort C, 1997–2000 for cohort D, and 2007–2010 for cohort E).

STATISTICAL ANALYSIS

The goal of the analyses was to examine the association between long-term improvements in ambient air quality and lung-function development in children from 11 to 15 years of age, measured as the increases in FEV_1 and FVC during that period (hereafter referred to as 4-year growth in FEV_1 and FVC). All available pulmonary-function measurements were used to estimate lung-function growth curves, including measurements at ages ranging from approximately 9 to 19 years in cohorts C and D and 10 to 16 years in cohort E. A previously developed linear-spline model,[5] with knots placed at ages 12, 14, and 16 years, was used to capture the nonlinear pattern of growth during adolescence (see the Supplementary Appendix for details). The model included adjustments for sex, race, Hispanic ethnic background, height, height squared, body-mass index (BMI, the weight in kilograms divided by the square of the height in meters), BMI squared, and presence or absence of respiratory-tract illness on the day of the pulmonary-function test. The model was constructed to yield estimates of the effects of pollutants on 4-year lung-function development (from 11 to 15 years of age) and on mean attained lung function at either 11 or 15 years of age. The range from 11 to 15 years of age was targeted because it covers the overlapping age period of pulmonary-function testing across cohorts. Follow-up over this age range was conducted from 1994 through 1998 in cohort C, from 1997 through 2001 in cohort D, and from 2007 through 2011 in cohort E. The estimated health effect of each pollutant is reported as the expected difference in lung-function growth associated with a difference in exposure equal to the median of the changes in pollution in the five communities over the course of the study period (Table 1).

In addition to examining 4-year growth from 11 to 15 years of age, we analyzed the cross-sectional pulmonary-function measurements obtained for 1585 children at the end of this period (mean age, 15 years) to determine whether changes in air quality over time were associated with clinically important deficits in attained FEV_1 and FVC. Using data from all three cohorts, we developed a linear prediction model for FEV_1 that included adjustments for age, sex, race and ethnic background, height, height squared, BMI, BMI squared, and the presence or absence of respiratory illness. This model explained 61% of the variance in FEV_1 and 69% of the variance in FVC measurements at 15 years of age (i.e., $R^2=0.61$ and 0.69, respectively). For each child, we determined whether the ratio of observed to predicted FEV_1 and FVC fell below each of three cutoffs for defining low lung function: 90%, 85%, and 80%. Logistic regression was used to test for temporal trends in the proportion of children with low lung function across cohorts after adjustment for community. A P value of less than 0.05 was considered to indicate statistical significance, under the assumption of a two-sided alternative hypothesis.

RESULTS

CHARACTERISTICS OF THE STUDY PARTICIPANTS

There were slightly more girls than boys (52% vs. 48%) in each of the three cohorts (Table S1 in the Supplementary Appendix). The mean age at the baseline pulmonary-function test was higher in cohort E (11.3 years) than in cohort C (10.9 years) and cohort D (10.9 years). The age-specific mean height did not differ significantly across cohorts at 11, 13, or 15 years of age. There was a significantly higher proportion of Hispanic children in cohort E than in cohorts C and D (58% vs. 31%

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Table 1. **Estimated Differences in 4-Year Lung-Function Growth for Median Decreases in Ambient Pollutant Levels.***

Lung-Function Measurement and Pollutant	Lung-Function Difference at 11 Years of Age		Lung-Function Difference at 15 Years of Age		Growth from 11 to 15 Years of Age	
	Mean (95% CI)	P Value	Mean (95% CI)	P Value	Mean (95% CI)	P Value
	ml		*ml*		*ml*	
FEV_1						
Nitrogen dioxide	119.2 (76.5 to 161.9)	<0.001	210.6 (156.0 to 265.2)	<0.001	91.4 (47.9 to 134.9)	<0.001
Ozone	15.0 (−38.5 to 68.6)	0.58	8.3 (−82.9 to 99.6)	0.86	−6.7 (−51.0 to 37.5)	0.77
PM_{10}	87.7 (50.2 to 125.2)	<0.001	153.2 (97.7 to 208.6)	<0.001	65.5 (27.2 to 103.7)	<0.001
$PM_{2.5}$	100.0 (58.9 to 141.2)	<0.001	165.5 (95.4 to 235.6)	<0.001	65.5 (17.1 to 113.8)	0.008
FVC						
Nitrogen dioxide	131.3 (91.0 to 171.6)	<0.001	300.2 (240.0 to 360.3)	<0.001	168.9 (127.0 to 210.7)	<0.001
Ozone	7.6 (−50.2 to 65.4)	0.80	0.3 (−126.0 to 126.5)	0.99	−7.3 (−79.3 to 64.6)	0.84
PM_{10}	93.8 (54.0 to 133.6)	<0.001	206.8 (124.6 to 289.1)	<0.001	113.0 (60.0 to 166.1)	<0.001
$PM_{2.5}$	110.1 (69.8 to 150.4)	<0.001	237.0 (147.2 to 326.7)	<0.001	126.9 (65.7 to 188.1)	<0.001

* The estimated means of community-specific pollution effects on lung-function values at 11 years of age and at 15 years of age and growth from 11 to 15 years of age are scaled to the median of the five community-specific declines in each air pollutant — specifically, 14.1 ppb in nitrogen dioxide, 5.5 ppb in ozone (10 a.m. to 6 p.m.), 8.7 μg/m³ in particulate matter with an aerodynamic diameter of less than 10 μm (PM_{10}), and 12.6 μg/m³ in particulate matter with an aerodynamic diameter of less than 2.5 μm ($PM_{2.5}$). For example, a decline of 14.1 ppb in nitrogen dioxide is associated with an increase of 91.4 ml in the growth of FEV_1 from 11 to 15 years of age (the mean of the five community-specific slopes).

and 33%, respectively). Cohort E also differed significantly from cohorts C and D with regard to several other factors, including exposure to passive smoke and pets (lower in cohort E) and the proportion of parents with health insurance (higher in cohort E) (Table S1 in the Supplementary Appendix).

CHANGES IN AIR QUALITY

Regional air quality has improved dramatically over the course of the Children's Health Study with respect to some pollutants (Fig. 1). The colored bands in Figure 1 represent the 4-year exposure periods for cohorts C (1994–1997), D (1997–2000), and E (2007–2010). For example, the 4-year mean $PM_{2.5}$ level in the community with the highest levels of particulate matter (Mira Loma) declined from 31.5 μg per cubic meter in cohort C to 17.8 μg per cubic meter in cohort E, a 43% reduction (Table S2 in the Supplementary Appendix). All five communities had large declines in levels of $PM_{2.5}$ and nitrogen dioxide. Changes in levels of PM_{10} and ozone over time were more modest (Fig. 1), as were changes in levels of PM_{10}–$PM_{2.5}$ (Fig. S3 in the Supplementary Appendix).

CHANGES IN LUNG-FUNCTION GROWTH

Across all three study cohorts, the mean FEV_1 among girls increased from 2274 ml at 11 years of age to 3150 ml at 15 years of age, for a mean 4-year increase of 876 ml (Table S3 in the Supplementary Appendix). Among boys, the mean FEV_1 was 2311 ml at 11 years of age and 3831 ml at 15 years of age, for a mean 4-year growth of 1520 ml. Similar magnitudes of growth were observed for FVC.

Increases in 4-year growth in both FEV_1 and FVC were associated with reduced levels of nitrogen dioxide, PM_{10}, and $PM_{2.5}$ within all five study communities (Fig. 2). When the effects were averaged across communities, we found that the mean 4-year growth in FEV_1 increased by 91.4 ml per decrease of 14.1 ppb in nitrogen dioxide level ($P<0.001$), by 65.5 ml per decrease of 8.7 μg per cubic meter in PM_{10} level ($P<0.001$), and by 65.5 ml per decrease of 12.6 μg per cubic meter in $PM_{2.5}$ level ($P=0.008$) (Table 1). At the beginning of follow-up (when participants were 11 years of age), significant increases in mean FEV_1 values were associated with decreases in levels of nitrogen dioxide, PM_{10}, and $PM_{2.5}$ (Table 1). However, the increases in mean FEV_1 at 15 years of

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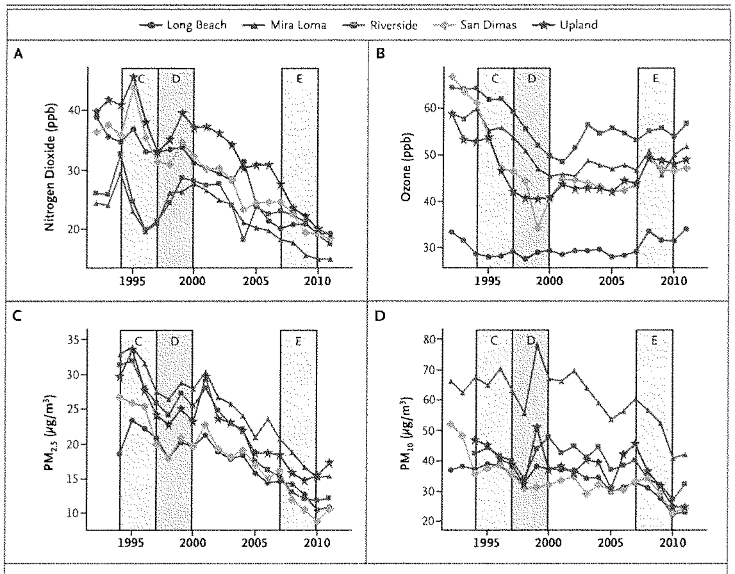

Figure 1. **Levels of Four Air Pollutants from 1994 to 2011 in Five Southern California Communities.**

Colored bands represent the relevant 4-year averaging period for the analysis of lung-function growth in each of the three cohorts, C, D, and E. PM$_{2.5}$ denotes particulate matter with an aerodynamic diameter of less than 2.5 μm, and PM$_{10}$ particulate matter with an aerodynamic diameter of less than 10 μm.

age, after 4 years of pollution-affected growth, were even more pronounced. Analogous effects were observed for FVC. Changes in ozone (Fig. 2) and PM$_{10}$–PM$_{2.5}$ (Fig. S4 in the Supplementary Appendix) were not associated with differences in mean FEV$_1$ or FVC values at 11 or 15 years of age or with 4-year growth in these values.

The estimated pollution-related effects on 4-year FEV$_1$ and FVC growth remained significant in sensitivity analyses (Table S4 in the Supplementary Appendix). For example, the associations between improved lung-function development and reduced nitrogen dioxide levels in Table 1 (shown as "base model" in Table S4 in the Supplementary Appendix) remained significant and of similar magnitude when additional adjustment was made for in utero or passive tobacco-smoke exposure, personal smoking, health insurance, parental education, asthma at baseline, or several indoor exposures, including cats, dogs, and mold or mildew. There were significant effects on lung-function growth in both boys and girls, although the magnitude of the air-pollution effect was significantly larger in boys than in girls with respect to both FEV$_1$ ($P=0.04$) and FVC ($P=0.001$). There were also significant pollution effects on lung-function growth in Hispanic white and non-Hispanic white children and in children with asthma and children without asthma. Although the magnitude of the nitrogen dioxide effect on 4-year growth in FEV$_1$ and FVC was nearly twice as large in children with asthma, as compared with children without asthma, the difference was not significant for either lung-function measure. Pollution-effect estimates were of a magnitude similar to those in the base model when the sample was restricted to children with complete 4-year follow-up data. Sensitivity analyses of the other pollutants yielded results similar to those for nitrogen dioxide

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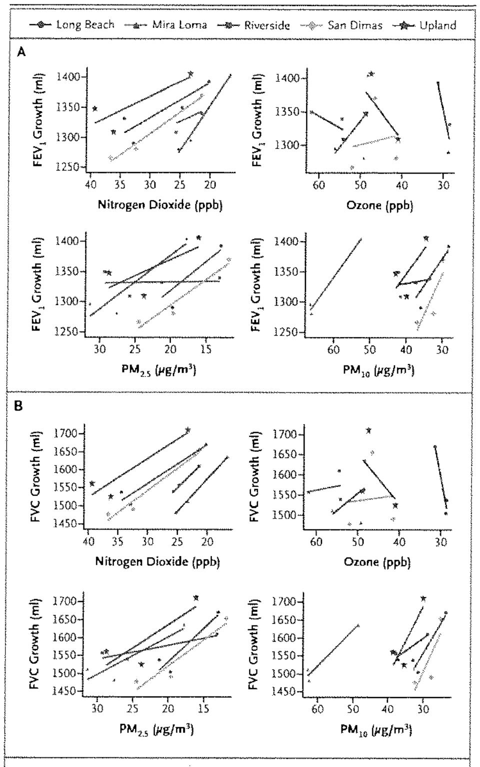

Figure 2. **Mean 4-Year Lung-Function Growth versus the Mean Levels of Four Pollutants.**

The mean growth in forced expiratory volume in 1 second (FEV$_1$) (Panel A) and the mean growth in forced vital capacity (FVC) (Panel B) from 11 to 15 years of age are plotted against the corresponding levels of nitrogen dioxide, ozone, PM$_{2.5}$, and PM$_{10}$ for each community and cohort.

(data not shown). We found no significant association between growth in height and change in pollution during the study period (Table S5 in the Supplementary Appendix), which indicates that our findings on lung-function growth are probably not the result of a secular trend in general development.

The large improvements in lung function associated with reduced air pollution (Table 1) suggest that the mean attained FEV$_1$ and FVC values at 15 years of age were substantially larger in cohort E (the cohort with the lowest level of exposure, as seen in Fig. 1) than in cohorts C and D. Further analysis of lung function at 15 years of age also revealed significant differences across cohorts in the proportion of children with low lung function (Fig. 3). For example, at a cutoff of 80% for the ratio of observed to predicted values, the proportion of children with low FEV$_1$ was 7.9% in cohort C, 6.3% in cohort D, and only 3.6% in cohort E ($P<0.005$). Similar significant trends were observed for FVC.

DISCUSSION

This study shows an association between secular improvements in air quality in southern California and measurable improvements in lung-function development in children. Improved lung function was most strongly associated with lower levels of particulate pollution (PM$_{2.5}$ and PM$_{10}$) and nitrogen dioxide. These associations were observed in boys and girls, Hispanic white and non-Hispanic white children, and children with asthma and children without asthma, which suggests that all children have the potential to benefit from improvements in air quality.

In addition to improvements in lung-function development from 11 to 15 years of age, we also found a strong association between a reduction in air pollution and a reduction in the proportion of children with clinically low FEV$_1$ and FVC at 15 years of age. In general, the age range of 11 to 15 years captures a period during which lungs are developing rapidly in both boys and girls. Lung-function development continues in girls until their late teens and in boys until their early 20s, but at a much-reduced rate as compared with the rate during the earlier adolescent period.[15,16] It is therefore likely that the improved function we observed in the children who were less exposed to the pollutants will persist into their adulthood. A higher level of lung function in early adulthood may decrease the risk of respiratory conditions.[17] However, the greatest benefit of improvements in lung-function development may occur later in life, because it has been shown that greater lung function in adulthood can contribnte to lower risks of premature death and other adverse health outcomes.[18-24] Consistent with the growth effects we have observed in children, there is evidence

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that reduced exposure to pollution in adulthood can slow the decline in lung function[25] and increase life expectancy.[26,27]

In southern California, motor vehicles are a primary source of $PM_{2.5}$, PM_{10}, and nitrogen dioxide, through direct tailpipe emissions as well as downwind physical and photochemical reactions of vehicular emissions.[28,29] Gasoline-powered and diesel-powered engines contribute to high levels of these pollutants, and improved emission standards for both types of vehicles have contributed to the observed declines in air pollutants. Control strategies implemented in the 1970s and 1980s focused primarily on reducing the levels of ozone, a pollutant with a long history of demonstrated acute health effects.[30] Although levels of ozone continued to decline in the 1990s and 2000s, the changes were smaller than for nitrogen dioxide and particulate matter, and we did not observe ozone-related effects on lung-function growth. This finding is consistent with our previous report that decreased lung-function growth was related to increased exposure to nitrogen dioxide and particulate matter but not to ozone.[6] Only a few other studies have addressed the long-term effects of ozone on lung function in children, and the results have been inconsistent.[31] Because of high correlations among reductions of $PM_{2.5}$, PM_{10}, and nitrogen dioxide (Table S6 in the Supplementary Appendix), we could not assess the independent associations between lung function and each of these pollutants. Many other studies have also been unable to identify the health effects of specific pollutants that are constituents of a multipollutant mixture.[3,32] However, the results of our investigation make it clear that broad-based efforts to improve general air quality are associated with substantial and measurable public health benefits.

A main directive of the 1970 U.S. Clean Air Act was to establish "...ambient air quality standards . . . allowing an adequate margin of safety . . . requisite to protect the public health . . . ." A basic tenet of the act is that changes in airborne pollutant levels can lead to improved public health and that the scientific evidence needed to determine the appropriate levels for those standards can be identified. Our observation of improvements in air quality and subsequent improvements in longitudinal respiratory health outcomes may provide objective evidence in support of that basic tenet.

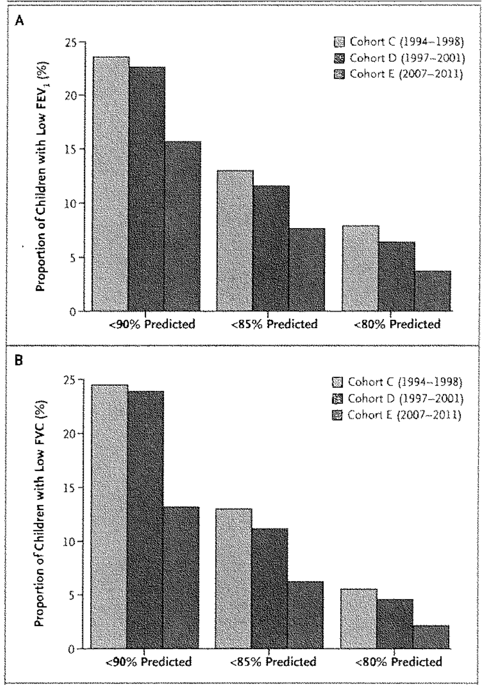

Figure 3. **Proportions of Children with Low Lung Function in Each Cohort.**

The proportions of children with lung function below 90%, 85%, or 80% of the predicted value at 15 years of age in cohorts C, D, and E are shown for FEV_1 (Panel A) and FVC (Panel B).

The data necessary to conduct this study were collected over a period of nearly two decades. Strengths of the study include the use of consistent protocols for collecting health, covariate, and air-quality data over the entire study period. Although the extended follow-up period can be viewed as a strength, it also presented several challenges. A change in spirometers during the course of the study was necessary to replace aging equipment and raises the issue of instrumental comparability. To address this, we conducted an additional analysis to show that our findings are robust to the use of different spirometers (Table S7 in the Supplementary Appendix).

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The change from annual testing in cohorts C and D to testing every other year in cohort E, as a result of budgetary constraints, may raise concern about dropout of participants in cohort E. In general, bias can occur in a cohort study if dropout depends simultaneously on both outcome and exposure. In our study, however, participant attrition during the follow-up period was not jointly associated with baseline lung function and several measures of exposure, including cohort membership and cohort-specific mean levels of nitrogen dioxide and particulate matter, the pollutants that showed significant associations with lung-function growth. In addition, the magnitude and significance of our observed growth effects were similar among participants with complete follow-up (Table S4 in the Supplementary Appendix), making it unlikely that selective dropout is responsible for our observed associations.

The shift in ethnic background across cohorts to a more Hispanic population, synchronous with general trends occurring more broadly in southern California,[33,34] raises potential concerns about confounding by factors specific to ethnic background. Also, because this is an observational study, it is possible that one or more additional factors associated with both lung-function growth and change in air quality over time could confound our pollution analyses. However, we conducted many sensitivity analyses and found that none of these factors appreciably affected our estimates or inferences. Furthermore, because the mean growth in height from 11 to 15 years of age did not vary over the study period, one might conclude that the change in growth is specific to the lung, with improvement in air quality serving as an important contributing factor.

Another limitation of our study is the lack of a pure "control" community — that is, a community in which there was no change in pollution during the study period. However, we studied five different communities with differing magnitudes of improvement in air quality, which collectively serve as five replicate experiments of our within-community temporal-trend experiment. We conducted an additional analysis that showed that the expected gain in lung function over time within any one community was aligned with the magnitude of improvement in air quality within that community (Fig. S5 in the Supplementary Appendix). The trends in these effects suggest that if we had had a pure control community, we would have seen little change in lung-function growth. This analysis also suggests that even modest improvements in air quality can lead to improved health, although with only five communities included in the study, we caution that we do not have adequate data to make definitive conclusions about the exposure–response relationship.

We have shown that improved air quality in southern California is associated with statistically and clinically significant improvements in childhood lung-function growth. The pollutants we found to be associated with lung-function growth — nitrogen dioxide, $PM_{2.5}$, and PM_{10} — are products of primary fuel combustion and are likely to be at increased levels in most urban environments. These pollutants were among those effectively reduced through targeted policy strategies. If we make the not-unreasonable assumption of causality, the magnitude of the effects we observed and the importance of lung function over the course of the human lifetime justify the efforts that have been made to improve air quality.

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Dr. McConnell reports holding a research contract from funds from an air-quality-violations settlement between the South Coast Air Quality Management District, a California state regulatory agency, and BP. No other potential conflict of interest relevant to this article was reported.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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OPINION

The Dubious Benefits of Further Ozone Reductions

The proposed EPA standard is very close to levels that are found naturally in some regions of the country.

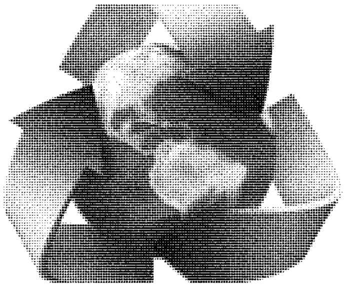
By **JULIE E. GOODMAN** And **SONJA SAX**
May 11, 2014 5:21 p.m. ET

Over the past several decades the U.S. has achieved remarkable success in reducing air pollution. According to the Environmental Protection Agency, the country has reduced six common air pollutants by 72% since 1970. These reductions are credited with achieving meaningful public-health benefits, from improved respiratory health to increased life expectancy.

Yet with this success we now face a critical question: Will further decreases in air pollution to levels that approach those that occur naturally necessarily result in additional public-health benefits? This question gets to the heart of the EPA's current evaluation of whether the existing National Ambient Air Quality Standard for ozone is sufficient to protect public health. Ozone is a colorless, odorless gas that is not directly emitted into air, but is formed when sunlight reacts with two other pollutants: volatile organic compounds and nitrogen oxides. These come from many natural sources (plants, forest fires) as well as human-made sources (cars, industrial facilities, power plants).

The Clean Air Scientific Advisory Committee, a panel of scientists and public-health experts charged by Congress with advising the EPA, met in March to discuss the agency's evaluation of the link between ozone and respiratory illnesses such as asthma and other health issues. The hope is that, with robust public input, the EPA and the committee will arrive at conclusions that accurately reflect the current state of scientific research on ozone. The stakes are significant: The EPA itself estimates that more-stringent standards could cost businesses up to $90 billion annually.

Currently the EPA standard for ozone in the air is 75 parts per billion, the strictest level since the standard was established in 1971. In 2008 the EPA determined, and a federal court agreed, that this standard protects public health. But now the EPA says that 75 ppb is not protective enough and is recommending a change to between 60 ppb and 70 ppb. Meanwhile, the overwhelming body of scientific evidence indicates lowering the current ozone standard will not provide added health benefits beyond those achieved with the current standard.



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There have been hundreds of scientific studies on ozone exposure and possible health effects, and the EPA has reviewed most of them. However, the EPA has not evaluated them in systematic fashion, by considering study strengths and limitations in a consistent manner from study to study. This type of analysis is called a "weight-of-evidence" evaluation, and it can help prevent the cherry-picking of studies—which can occur when scientists focus on studies or evaluate data that confirm their position, or when the scientists place less emphasis on studies that do not.

Most studies examining connections between ozone and health effects do not adequately account for smoking or other factors such as diet and exercise that could contribute to diseases attributed to ozone. By not fully considering these other factors, the EPA assumes that ozone causes more health effects than what the science supports.

The EPA also has interpreted some studies to indicate that ozone is more harmful than it likely is. For example, Dr. William C. Adams, professor emeritus at the University of California, Davis, published a peer-reviewed paper in 2006 concluding that 60 ppb ozone exposures to people exercising for six hours did not lead to harmful respiratory effects. The EPA "reanalyzed" his data and determined that it did. Dr. Adams later said, on the EPA Docket for public comment, that the "EPA has misinterpreted the statistics contained in my published, peer-reviewed paper."

This kind of discrepancy should give the Clean Air Scientific Advisory Committee pause as it evaluates the health effects of ozone.

The EPA considers worst-case scenarios arguably to protect the most sensitive people in a population. However, in its ozone health-risk and exposure assessment, the EPA makes many "worst-case" assumptions that could not all occur at one time, leading to an unrealistic scenario that overestimates risks.

The lowered standard that the EPA is proposing (between 60 and 70 ppb) is very close to levels of ozone that are found naturally in some regions of the country. For example, the ozone level at Big Bend National Park in southwest Texas, where there are no industrial facilities, is 71 ppb.

Significantly, the EPA's models have shown that decreasing human-made sources of ozone could actually lead to increased natural ozone in some areas. This happens because ozone formation is complex, and nitrogen oxides both form and destroy ozone. By controlling human sources of nitrogen dioxide to achieve lower ozone levels, many parts of the country will not be able to meet current ozone standards solely because of naturally formed ozone.

We all want appropriate standards to ensure that our air is clean. But the EPA shouldn't lower the ozone standard unless there is solid evidence that doing so would result in measurable improvements in health or reductions in the diseases associated with air pollution.

Drs. Goodman and Sax consult for business and government on issues relating to the EPA's air-pollution standards. Dr. Goodman also is an adjunct faculty member of the Harvard School of Public Health.

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Office of the Governor

Phone: (785) 296-3232
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governor.ks.gov

Sam Brownback, Governor

February 24, 2015

The Honorable Gina McCarthy
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Dear Administrator McCarthy,

In the four decades since the Clean Air Act was signed into law, my state has seen improvements to the quality of the air we breathe. We have done so while adhering to the principle that protection of the environment does not need to sacrifice economic progress if each is done properly. It is for this reason that I oppose changing the National Ambient Air Quality Standard (NAAQS) for ground-level ozone at this time.

Many areas may be closed off to new business by being placed in "nonattainment;" an economic penalty box that makes it so difficult to grow that many businesses refuse to build or expand. As much as 60 percent of the technologies needed to comply with a new standard are unknown even to the EPA. If these controls are not invented in time, businesses will be forced to consider scrapping existing plants and equipment. The end result is an economy where consumers will have less to spend on food, clothing and other basic needs because they will be spending this money instead on the new costs that have been passed through to them from ozone regulations.

Furthermore, my state is currently in the process of implementing dozens of massive new regulations put in place by your agency over the past several years. Regulations like the Mercury and Air Toxics Standards, the Boiler MACT, fuel economy standards for cars and trucks, regional haze rules, the Cross-State Air Pollution Rule, Tier 3 tailpipe emissions standards, and of course the Clean Power Plan. A byproduct of these regulations hopefully is reductions in the emissions that cause ozone, making a new NAAQS unnecessary. Taken together, these regulations impose billions of dollars in new costs on my state and its citizens. Additional regulations are not needed.

We have only begun to implement the ozone NAAQS put in place in 2008—standards for which implementation guidance has not even been issued by the EPA. The EPA continues to strain our resources by imposing upon us a steady stream of complex and expensive new regulations. This is already costly and difficult.

Your agency has proposed the most expensive regulation in our nation's history. It is unnecessary and damaging to Kansans. It is my duty to my constituents to oppose it. We ask you to reconsider and instead keep the current standard of 75 parts per billion (ppb) in place.

Sincerely,

Sam Brownback
Governor of Kansas

Just how much is Asia's ozone to blame for bad air in the U.S.?

By TONY BARBOZA

JANUARY 31, 2015, 2:00 PM | CARMEL VALLEY, CALIF.

High above the Big Sur coast, Ian Faloona is finding pollution on the edge of the continent, a place that should have some of the country's cleanest air.

From an astronomical observatory on Chews Ridge in the Santa Lucia Mountains, the UC Davis atmospheric scientist has for the last three years measured ozone, the lung-damaging gas in smog, as it arrives to California. The monitoring site, more than 5,000 feet above sea level on a pine-studded overlook above the lowest layer of the atmosphere, gives Faloona access to undisturbed air from across the Pacific before it is fouled by U.S. pollution sources.

He and other scientists at rural, high-altitude sites across the western U.S. have been documenting rising levels of ozone, which can trigger asthma attacks, worsen heart and lung disease and lead to premature deaths, even as emissions have plummeted nationwide over the last few decades.

Soaring emissions from China and other fast-growing Asian countries are blowing across the Pacific Ocean, they say, increasing baseline levels of ozone in the western U.S. In about a week, winds carry ozone formed by emissions from cars, factories and power plants in Asia to the U.S. West Coast, where it can add to locally generated pollution, worsening smog in cities such as Bakersfield, Fresno and Los Angeles.

The phenomenon is fueling a debate about just how much Asia is to blame for bad air in the U.S., one that could soon have health consequences for people across the West.

Experts say that as U.S. air quality improves, Asian emissions — previously thought to have a negligible effect here — are having a stronger influence on smog levels, particularly in western states that sit at higher elevation and arefirst exposed to the pollutants. In a development that has troubled health advocates, some local pollution regulators have begun arguing that they should not be penalized if Asian pollution is causing local smog to exceed health standards under the Clean Air Act.

Spearheading that effort is the San Joaquin Valley Air Pollution Control District, which regulates industry to protect nearly 4 million people from Stockton to

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research, and this spring at Yosemite National Park, it is sponsoring a three-day transboundary ozone pollution conference for scientists and policymakers.

Last year, the agency submitted a first-of-its-kind petition to the U.S. Environmental Protection Agency asking to be exempted from penalties for violating a health standard because of ozone pollution from Asia. On Aug. 10, 2012, pollution from Asia pushed smog levels in Fresno above a federal standard, the air district said.

The EPA imposed penalties on the region after it failed to meet a 2010 deadline to clean up ozone pollution. Valley air quality regulators have since collected more than $100 million in fines, mostly through an extra $12 a year in vehicle registration fees.

"Our residents shouldn't be penalized for pollution that comes from elsewhere," said Seyed Sadredin, executive director of the San Joaquin Valley air quality district.

The EPA did not act on the San Joaquin Valley air district's request, saying that it was not submitted through the appropriate process and that the district can meet the health standard violated despite the added pollution from Asia.

Jed Anderson, a Houston-area lawyer who focuses on air quality compliance, said the request by the San Joaquin Valley is "not going to be unique for very long." It opens the door for air quality agencies across the nation to consider foreign pollution as a factor in local air quality violations.

The EPA has proposed tightening ozone limits, from 75 parts per billion to between 65 and 70 parts per billion, later this year. A new standard would put more areas of the country in violation of air quality standards and place parts of the West in a tough spot between a rising baseline of ozone and stricter federal limits.

Limiting pollution flowing in from Asia would require an international treaty, said Owen Cooper, an atmospheric scientist at the Cooperative Institute for Research in Environmental Sciences in Boulder, Colo.

Such a deal is unlikely, leaving U.S. regulators to eke out further cuts in smog-forming pollutants, he said. "Here in Denver, our emissions have come

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traps pollution, have long attributed the region's dirty air to factors other than local industry, including cars and refineries in the Bay Area and long-distance truckers on Interstate 5. Their recent focus on ozone from Asia has drawn renewed criticism from health advocates, who say state and local regulators should devote their resources to curbing emissions from cars, factories, farms and other sources they have the power to control.

Dolores Weller, director of the Central Valley Air Quality Coalition, says the air district's attention to ozone from Asia is the latest example of officials "not focusing in on homegrown pollution and continuing to look for exemptions and further excuses."

"It's just an easier target for an air district under pressure from local industries," Weller said.

Although estimates vary, recently published studies have found that Asian ozone contributes 3 to 8 parts per billion of the pollution in low-elevation parts of Southern California, such as Bakersfield and Los Angeles, and up to 15 in high-elevation regions of the West. It's a small contribution but could make the difference between a bad air day and one that meets the current health standard of 75 parts per billion.

On Chews Ridge, Faloona and his graduate assistant, Andrew Post, have measured ozone concentrations as high as 80 parts per billion. They have also found evidence that the gas is sinking and mixing into the air in the San Joaquin Valley, boosting smog levels in such cities as Bakersfield and Fresno.

A portion of the ozone blowing into California is natural, migrating down from the stratosphere or formed from compounds released by plants. Winds transport the most ozone pollution from Asia during the spring, not during the height of smog season in late summer.

Although it's a concern, ozone from Asia is not as significant a problem as San Joaquin Valley pollution regulators make it out to be, said Jared Blumenfeld, administrator for the EPA's Pacific Southwest region.

"We can't put too great an emphasis on sources that may not have a large contribution,' Blumenfeld said.

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concerns.

That's what Faloona sees from his ridge-top monitoring site: Two air-quality problems that are no longer divorced from one another.

To the west, he can see a sliver of the Pacific Ocean, where his air quality monitor's plastic intake tube is pointed and pumping away. Looking inland, he sees the San Joaquin Valley, blanketed in a layer of air pollution.

"People think of these pollutants as relatively short-lived and think they don't make it that far," Faloona said. "But we've realized it's all connected."

tony.barboza@latimes.com

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Goodman *et al.* In Press.

Are the Elements of the Proposed Ozone National Ambient Air Quality Standards Based on the Best Available Science?

Julie E. Goodman, Sonja N. Sax , Sabine Lange, Lorenz R. Rhomberg
Reg. Tox. Pharm. In press.

Abstract

There is widespread misunderstanding about how controlled human exposure and epidemiology studies should be considered by the US Environmental Protection Agency EPA (US EPA) when assessing the adequacy of the proposed ozone National Ambient Air Quality Standards (NAAQS). Controlled human exposure studies involved small numbers of people performing quasi-continuous exercise for a long duration at an intensity not common in the general population, unlikely achievable by most sensitive individuals, and under worst-case exposure profiles. Epidemiology studies used different averaging times and have methodological limitations that may have biased results; this makes it challenging to compare results across studies and appropriately apply results in a NAAQS evaluation. The NAAQS has four elements – indicator, level, averaging time, and form – and it does appear that each of these elements was fully considered when controlled human exposure and epidemiology studies were reviewed as part of the NAAQS process. Relating patterns and circumstances of exposure, and exposure measurements, from experimental and observational studies to all elements of the NAAQS can be challenging, but if US EPA did this, it would be evident that available studies do not indicate that proposed lower NAAQS will be more health protective than the current one.

1 Introduction

The Clean Air Act (CAA) was first passed in 1963. In 1970, amendments to the CAA required the listing of air pollutants that "may reasonably be anticipated to endanger public health and welfare" and that the United States Environmental Protection Agency (US EPA) issue National Ambient Air Quality Standards (NAAQS) for them. In 1971, US EPA first set NAAQS for photochemical oxidants (later regulated as ozone), carbon monoxide, lead, nitrogen oxides (NO_x) (regulated as nitrogen dioxide), particulate matter (PM, later regulated as total suspended particulates, then as PM_{10}, and $PM_{2.5}$), and sulfur oxides (regulated as sulfur dioxide) – collectively called criteria pollutants.

Section 109 of the CAA (1970) directs the US EPA Administrator to propose and promulgate "primary" and "secondary" NAAQS for criteria pollutants. Primary standards are intended to protect public health, including that of sensitive populations (*e.g.*, asthmatics, children, and the elderly). Specifically, the legislative history of section 109 indicates that a primary standard is to be set at "the maximum permissible ambient air level... [that] will protect the health of any [sensitive] group of the population," and that, for this purpose, "reference should be made to a representative sample of persons comprising the sensitive group rather than to a single person in such a group" S. Rep. No. 91–1196, 91st Cong., 2d Sess. 10 (1970). Secondary standards are intended to prevent welfare effects, which are described in section 302(h) (42 U.S.C. 7602(h)) as including, but not being limited to, "effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being." The present commentary is focused on the ozone primary standard, but most of its points are applicable to other criteria pollutants and to secondary standards, as well.

Ozone is a secondary air pollutant that is formed by photochemical reactions between precursor gases, primarily NO_x and volatile organic compounds, in the presence of ultraviolet rays from the sun. Typically, ozone concentrations begin increasing as the sun rises, reach a peak near mid-day, and decrease markedly after sunset (US EPA, 2006). Ozone formation and breakdown are complex and depend on the relative concentrations of precursor gases and meteorological factors (*e.g.*, sunlight intensity and atmospheric mixing); thus, ambient ozone concentrations vary widely both spatially and temporally (US EPA, 2013a). Mean background ozone concentrations across the US range from 0.027-0.040 ppm during the spring and summer, and sometimes reach higher than 0.060 ppm in the intermountain West (Zhang *et al.*, 2011; Vingarzan, 2004; US EPA, 2013a). In some places, background concentrations contribute to over 80% of total ozone, which can make compliance with the current ozone NAAQS challenging (Zhang *et al.*, 2011).

Each NAAQS has four elements: an indicator, an averaging time, a level, and a form (US EPA, 2013a). The indicator defines the pollutant that is measured in ambient air so that one can determine compliance with the standard. The indicator for photochemical oxidants is ozone. The averaging time is the period over which air quality measurements are averaged or cumulated, considering evidence of effects associated with various time periods of exposure (*e.g.*, 1-hour, 8-hour, 24-hour, annual). The level defines the acceptable numerical air quality concentration of the indicator. Finally, the form of the standard provides the appropriate statistical basis to consider (*e.g.*, a percentile or mean) and whether it should be averaged over several years. All of these elements must be taken into account to determine compliance with a standard.

Several elements of the ozone NAAQS have changed since it was first promulgated in 1971 (Table 1; reviewed by McClellan *et al.*, 2009). From 1971 to 1979, the indicator was photochemical oxidants; since then, it has been ozone, the most prevalent oxidant. Until 1997, the primary ozone standard was a daily 1-hour maximum concentration of 0.12 parts per million (ppm) that was not to be exceeded more than once a year. Attainment of the 1-hour standard could vary from year to year in a given area, depending primarily on meteorological conditions (NRC, 1991). In 1997, US EPA determined that an 8-hour averaging time for ozone would provide greater stability for meeting the standard and more accurately reflect the way humans respond to ozone (Anderson and Bell, 2010). With the change in the averaging time from a 1-hour daily maximum to a daily 8-hour average maximum, the level of the standard was reduced from 0.12 to 0.08 ppm (equivalent to 0.084 ppm using standard rounding conventions). In 2008, the ozone NAAQS was revised so that the annual fourth-highest daily maximum 8-hour concentration, averaged over three years, should not exceed 0.075 ppm. The US EPA Administrator has now recommended lowering the level of the standard to between 0.065 and 0.070 ppm (US EPA, 2014b).

The CAA requires that US EPA review the health effects evidence for each criteria pollutant every five years to determine whether new evidence suggests the need to change the NAAQS. The NAAQS review process includes a literature review and synthesis by US EPA staff and consultants, review and comment by the Agency's Clean Air Scientific Advisory Committee (CASAC), and public review and comment. First, US EPA evaluates the body of available scientific literature to draw conclusions regarding the weight of evidence for causal relationships between exposure to criteria pollutants and human health and welfare effects in an Integrative Science Assessment (ISA) (US EPA, 2013a). Building on the information in the ISA, US EPA prepares a Health Risk and Exposure Assessment (HREA) to place the scientific evidence reviewed in the ISA into the context of past, current, and projected exposure conditions and associated risks (*e.g.*, US EPA, 2014a). Based on the ISA and HREA, the Agency summarizes the key scientific information associated with various options for re-affirming or revising the

NAAQS in a Policy Assessment (PA) (*e.g.*, US EPA, 2014c). At the final stage, the US EPA Administrator releases a proposal for re-affirmation or revision of the NAAQS for public comment (Proposed Rule), followed by the promulgation of a final NAAQS (Final Rule). Ultimately, while the US EPA Administrator's conclusions regarding the elements of the NAAQS are based on the scientific evidence, the NAAQS elements are a policy judgment regarding an acceptable level of risk (McClellan, 2012).

The types of scientific studies US EPA considers when evaluating the weight of evidence for causal associations and for estimating human health risks include controlled human exposure, epidemiology, and experimental studies. In the current ozone evaluation, US EPA appears to give the most weight to controlled human exposure and epidemiology studies. Mode-of-Action (MoA) evidence, or information regarding functional or anatomical changes at the cellular level, is also considered by US EPA to a limited extent, but it doesn't appear that US EPA relies on MoA studies to inform the level of the proposed standard. US EPA does not seem to fully consider the form or averaging time of the standard when evaluating any of these studies.

US EPA (2014b) concludes that there is a causal association between short-term ozone exposure and respiratory effects, and likely causal associations between long-term ozone exposure and respiratory effects (including mortality), as well as short-term ozone exposure and total non-accidental mortality and cardiovascular effects (including mortality). We have discussed the evidence regarding cardiovascular effects and all-cause mortality in detail elsewhere (Goodman *et al.*, 2014; Prueitt *et al.*, 2014; Goodman and Sax, 2012). Below, we discuss some of the issues associated with the use of controlled human exposure and epidemiology studies to inform the various elements of the NAAQS, using ozone and respiratory effects as an example.

2 Controlled Human Exposure Studies

In the controlled human exposure studies, subjects were exposed to ozone through a facemask inhalation system or *via* whole-body exposure in an environmental chamber for several hours, often while performing quasi-continuous exercise. Almost all studies included a control scenario in which subjects were exposed to filtered air with no ozone.

Several controlled ozone exposure studies evaluated short exposure durations (2-2.5 h), with exposures ranging from 0.1-0.5 ppm (McDonnell *et al.* 1983; Seal *et al.* 1993; Adams 2003; Folinsbee 1978); others evaluated longer exposure durations (6.6-7.6 h), with exposures ranging from 0.04 to 0.12 ppm (McDonnell 1991; Adams 2002; Adams 2006; Schelegle *et al.* 2009; Kim *et al.* 2011; reviewed by Goodman *et al.* 2014). Studies with exposure times closer to eight hours are most applicable to the NAAQS because that is currently the averaging time of the standard.

Most of the studies measured forced expiratory volume in one second (FEV_1) and symptoms (*e.g.*, cough, shortness of breath, tearing, eyes burning, throat and nose irritation, chest pain on deep inspiration, headache, dizziness, nausea, confusion, and sweating), while some have also reported forced vital capacity (FVC) and the FEV_1/FVC ratio, and a few have evaluated inflammatory biomarkers (Devlin *et al.* 2012; Mudway *et al.* 2001; Aris *et al.* 1993; Scannell *et al.* 1996).

Most studies used square-wave exposures (*i.e.*, ozone concentrations were maintained at a constant level throughout the exposure period), but Adams (2003, 2006), Schelegle *et al.* (2009), and Hazucha *et al.* (1992) used triangle exposures (*i.e.*, exposure increased step-wise and then decreased step-wise to achieve a target average exposure concentration). The triangular exposure profile may better approximate the typical pattern of daytime ambient ozone concentrations than the square-wave profile, but the specific patterns used may not reflect typical diurnal patterns. For example, the protocols used for the 0.072 and

Goodman *et al.* In Press.

0.088 ppm exposure scenarios in Schelegle *et al.* (2009) were the most extreme scenarios among ten "candidate" hourly measurements of 6-hour sequences (averaging 0.065-0.088 ppm) across several cities (Lefohn and Hazucha, 2005). These represent worst-case scenarios in specific locations, not what would be expected on average on a typical day, and thus may not be directly related to the standard.

Based on these studies, the US EPA Administrator concludes that respiratory effects are generally consistent with exposures greater than 0.08 ppm (US EPA, 2014b). The question at issue is whether adverse effects occur at exposure levels below the current NAAQS, and if so, what is the lowest exposure level at which this occurs? Although she considers the studies by Adams (2002, 2006) which showed no effects below the current level of the standard, the Administrator relies more heavily on the studies by Schelegle *et al.* (2009) and Kim *et al.* (2011) to address this. Small decrements in pulmonary function (*i.e.*, small decreases in mean FEV_1 values with no or slight changes in FVC) were reported at 0.06 ppm by Kim *et al.* (2011) and at 0.072 ppm (but not at 0.063 ppm) by Schelegle *et al.* (2009). US EPA concludes that these effects are adverse, while others have argued that they are more likely indicative of homeostatic processes (*e.g.*, see Goodman *et al.*, 2014; Pelligrino, 2010).

Physical activity increases both the ventilation rate and the distribution of ozone in the lung, which in turn increases the dose and the depth in the lung of inhaled ozone relative to an individual at rest. In the four studies with exposures below the current level of the NAAQS (Adams, 2002, 2006; Schelegle *et al.*, 2009; Kim *et al.*, 2011), subjects performed 50 min of continuous exercise followed by 10 min of rest each hour, during a 6.6 hour exposure period, to maintain an exercise ventilation of 20 L min^{-1} m^{-2} body surface area. US EPA (1996) stated that the exercise level in these studies should be considered moderate based on guidelines it published previously for representative types of exercise (see US EPA, 1986, Table 10-3). However, in the current HREA, US EPA (2014a) concluded that 13 L min^{-1} m^{-2} body surface area indicates "moderate or greater exertion." Also, Folinsbee *et al.* (1988) and McDonnell *et al.* (1991) noted that the exercise regimen common to almost all human controlled exposure studies simulates work performed during a day of heavy manual labor common in outdoor workers. This indicates that the exercise level maintained in these controlled exposure studies is likely much more strenuous and does not directly apply to the general population, with the exception of some outdoor workers. In particular, it does not apply to the most sensitive populations (*e.g.*, asthmatics), whose conditions would likely prevent them from achieving the ventilation rates required to produce the reported small decrements in lung function with ozone exposure. It also does not consider that most people spend a significant portion of their day indoors, where ozone levels are well below the exposures in these studies (reviewed by McClellan *et al.*, 2009). Chang *et al.* (2000), for example, reported exposures that averaged 0.015 ppm in the summer and only 0.0036 ppm in the winter over a 12 hour period during the day. There is no aspect of the NAAQS that accounts for the ventilation rate of the exposed population, despite this being an important component of each individual's total ozone dose. Because of this, ventilation rate is tied to the level of the NAAQS, such that the level should represent not only the ozone concentration, but also the total dose.

It should also be noted that these studies evaluated a small number of people, and it is inappropriate to extrapolate results from such a small sample size (with a very small number of ozone responders) to the US population as a whole. These studies involved people performing quasi-continuous exercise for an extended period of time at an intensity not likely achievable by most sensitive individuals, such as asthmatics, and under exposure profiles that likely represent worst-case scenarios. Also, because compliance with the NAAQS is conservatively based on the single highest monitor in each urban area, as indicated by the Administrator in the Proposed Rule, compliance with the current NAAQS will prevent some daily exposures of ozone concentrations evaluated in these studies (US EPA, 2014a,b).

The ultimate goal of the NAAQS is to protect the health of the general population, including sensitive groups, and not necessarily people who exercise in chambers for 6 hours or more while being exposed to ozone under worst-case exposure profiles. Ideally, controlled exposure studies would have evaluated

Goodman *et al.* In Press.

ozone exposure over a range of ventilation rates (including while at rest), under more realistic exposure scenarios, so that results could be applied to the general and sensitive populations. In the absence of studies that address these issues, assessing the adequacy of the NAAQS necessitates careful consideration of how exposures and effects reported in the available studies should be interpreted and related to expected exposure scenarios and effects in the general population. When this is done, it is evident that these studies do not indicate a lower NAAQS level with the current averaging time and form will be more health protective than the current one.

3 Epidemiology Studies

Epidemiology studies evaluate associations between air quality (usually measured by central air monitors) and health effects in the population. Time-series analyses and panel studies are often conducted to evaluate short-term exposures. In time-series studies, associations between time-varying ozone exposure and health are evaluated as they change on a day-to-day basis based on aggregate estimates of exposure and outcomes. In contrast, in panel studies, the health status of each subject is repeatedly assessed (in some cases, hundreds of times) as exposure varies from day to day, and each subject serves as his or her own control. Longitudinal cohort studies are often used to evaluate long-term exposures. In these studies, a large cohort of individuals is followed for several years, and a long-term average ozone exposure estimated for each individual is compared to the incidence of adverse outcomes. Researchers can control for important individual-level characteristics that may be associated with ozone exposures in these studies, but may not have enough reliable information to completely account for these factors.

Below we discuss in more detail factors that impact the interpretation of ozone epidemiology studies and how they bear on the assessment of the NAAQS averaging time and level.

3.1 Averaging Time

Averaging times are determined based on either acute (intense, short-term) or chronic (long-term) effects. The most common averaging times used to evaluate short-term health effects are the maximum 1-hour average within a 24-hour period (1-hour maximum), the maximum 8-hour average within a 24-hour period (8-hour maximum), the 12-hour average, and the 24-hour average. Most studies report risks based on different increments of ozone concentrations (*e.g.*, an increase in mortality per 0.01 or 0.02 ppm increase in ozone). In addition, studies often evaluate several lag times (the lag time is the time between an exposure and the occurrence of a health effect, *e.g.*, in two days or between zero and two days).

As acknowledged by US EPA (US EPA, 2014a) and the National Research Council of the National Academies of Sciences (NRC, 2008), the use of different averaging times, increments of ozone exposure, and lag times among studies has made it challenging to compare results across studies. For example, several studies have found that mortality risk estimates vary depending on the averaging times used (see Figure 2; Yang *et al.*, 2012; Hunova *et al.*, 2013; Moshammer *et al.*, 2013; Smith *et al.*, 2009).

The averaging time of the ozone NAAQS is an 8-hour maximum concentration. In an attempt to compare findings from different studies using different averaging times directly to the averaging time of the NAAQS, US EPA used a simple ratio (US EPA, 2013a). For example, US EPA converted risks associated with a 1-hour ozone maximum concentration so that they would be equivalent to risks associated with an 8-hour maximum concentration by multiplying by a constant. US EPA estimated each ratio by comparing measured ambient air concentrations across the US at different averaging times. That is, US EPA assumed a ratio of 2:1.5:1 for averaging times of 1-hour maximum: 8-hour maximum: 24-hour average ozone, based on the observation that average 1-hour maximum ozone concentrations are generally twice as high as 24-hour average concentrations, and 8-hour maximum concentrations are generally 1.5 times as high as 24-hour average concentrations (Anderson and Bell, 2010). US EPA then standardized mortality risk estimates using these ratios so they would have equal risks based on a 0.04 ppm increase in ozone for a 1-hour maximum exposure, a 0.03 ppm increase in ozone for an 8-hour maximum exposure, or a 0.02 ppm increase in ozone for 24-hour average exposure, all of which US EPA assumed to be equivalent (US EPA, 2013a).

Anderson and Bell (2010) assessed this methodology by evaluating 78 communities in the US in 2000 and 2004; they observed that ratios of ozone concentrations based on different averaging times varied across communities and over time. Average ratios for different ozone metrics ranged widely from 1.08-1.26 for the 1-hour: 8-hour ratio, from 1.23-1.83 for the 8-hour: 24-hour ratio, and from 1.35-2.20 for the 1-hour: 24-hour ratio. They found no clear regional patterns. The ratios also varied by season; for most communities, ratios were highest in the spring. This analysis demonstrated that when epidemiology studies use different exposure metrics, one cannot easily scale risk estimates to facilitate comparisons across studies and that this methodology could result in biased risk estimates.

Rather than convert averaging times in epidemiology studies, EPA should base the NAAQS on studies that use appropriate averaging times relative to the current NAAQS averaging time. It would be optimal to set an averaging time that was informed by ozone's MoA (*e.g.*, overwhelming anti-oxidant defenses, which should happen in a matter of hours). This would result in a NAAQS averaging time that more accurately reflects how people might adversely respond to ozone.

3.2 Level

The epidemiology studies on which US EPA relies to assess the adequacy of the ozone NAAQS level have limitations that impact the interpretation of results. Exposure measurement error, inadequate control of confounders, and inappropriate statistical models (*e.g.*, that assume no threshold or evaluate inappropriate lags) can all bias results away from the null (Rhomberg *et al.*, 2011; Goodman *et al.*, 2014).

The majority of ozone epidemiology studies rely on central ambient monitors to provide community-average ambient ozone exposure concentrations. The accuracy of epidemiology associations is predicated on the assumption that these measurements reflect personal exposures, yet many studies have found poor correlations between ambient ozone levels measured at central-site monitors and personal exposures (*e.g.*, Sarnat *et al.*, 2001; 2005), indicating a high degree of exposure measurement error. Rhomberg *et al.* (2011) demonstrated that exposure measurement error can linearize concentration-response functions (CRFs), and that this generally leads to an overestimate of risks at lower exposures. Meng *et al.* (2005) hypothesized that potential biases can arise in $PM_{2.5}$ associations because of seasonal variations in infiltration behavior. Their hypothetical scenario is entirely applicable – if not more likely – for ozone. Also, when ozone and other pollutants in statistical models are all subject to measurement error, the pollutant with the smallest error often displays the strongest associations, even if there is no true association (Zeger *et al.*, 2000).

The impact that co-pollutants and other confounding factors can have on the magnitude and direction of associations between ozone and various health effects differs in short- and long-term studies. In fact, sometimes single-pollutant models yield significant results for several correlated pollutants in the same dataset, and this is not fully considered by US EPA. Associations between short-term ozone exposure and health status can be impacted by factors that change on a day-to-day basis, such as meteorology (*e.g.*, temperature and relative humidity), co-pollutants, pollen and other aeroallergens, and respiratory infections. Long-term studies are often confounded by individual-level factors that are only measured once over a long time period and that sometimes are affected by self-reporting errors (*e.g.*, people under-report smoking or underestimate body mass index; Stommel and Schoenborn, 2009). These errors can affect associations in either positive or negative directions in long term-studies (Fewell *et al.*, 2007).

Goodman *et al.* In Press.

Model misspecification occurs when a statistical model does not accurately reflect true relationships between health and covariates, including exposure and potential confounders. Inappropriate control for confounders is one way that model misspecification can occur. It can also occur when thresholds or appropriate lag times are not fully considered. US EPA has indicated that there is no evidence of an ozone threshold in the epidemiology literature, but several researchers have reported thresholds (*e.g.*, Stylianou and Nicolich, 2009; Xia and Tong, 2006; Smith *et al.*, 2009). As discussed by Rhomberg *et al.* (2011), the reason why it may be challenging to identify a threshold for ozone effects in epidemiology studies stems from exposure measurement error, which can linearize CRFs, masking the true threshold. Also, evidence from both toxicology and controlled exposure studies indicate respiratory (and inflammatory) effects have thresholds. Thus, thresholds should be incorporated in statistical models.

In addition, several studies evaluate inappropriate lag times. For instance, the MoA for respiratory effects indicates that the maximal effects occur within hours and resolves within a couple days (*e.g.*, Gold *et al.*, 1999). Therefore, lung function effects should be observed within one or two days of elevated exposure in epidemiology studies. Several studies, however, report a lack of association between ozone and lung function at these short lags, but a positive association at longer lags, suggesting that results may be impacted by unaddressed confounding, measurement errors, or other methodological shortcomings. For example, Mortimer *et al.* (2002) reported decrements in morning peak expiratory flow (PEF) three days following exposure, but a null association at a one-day lag. In another study by Wiwatanadate *et al.* (2010), PEF was reduced on lag day five, but was non-significantly elevated on the same day as exposure.

US EPA should more fully consider these issues with epidemiology studies when determining how their results are extrapolated to the level of the NAAQS. When considered together in light of these limitations, these studies do not support a standard with a lower level.

4 Form

Finally, an area is considered to be out of compliance, or in non-attainment, if the annual fourth-highest daily maximum, averaged over three years, at a *single* monitor in that area is above the standard (Federal Register, 2012a,b). The area of non-attainment includes all counties that could contribute to the high reading at that single monitor. For example, there are 21 monitors in the Houston-Galveston-Brazoria area, and eight counties were in non-attainment in 2014 because three of the 21 monitors (present in three counties) indicated air quality that did not meet the NAAQS (TCEQ, 2013).

US EPA has iteratively modeled decreasing the US anthropogenic emissions of NO_x and volatile organic compounds until the design values for all monitors in an urban area are below the level of the standard (US EPA, 2014a). Because the highest monitor is what determines compliance, based on US EPA's models, other monitors will be farther below the standard.

It appears to be underappreciated that, with the current standard of 0.075 ppm, all areas in attainment can only have monitors with values over 0.075 ppm three times in a year, and that, because this can only be the case for the highest monitor, most other areas won't approach this level. For example, the 18 monitors meeting the current ozone standard in the Houston-Galveston-Brazoria area in 2014 measured fourth highest, three-year average ozone concentrations of 66-75 ppb, whereas the design value for the entire 8-county area was 80 ppb.

Goodman *et al.* In Press.

5 Conclusions

There is widespread misunderstanding of how controlled exposure and epidemiology studies should be considered by US EPA for developing NAAQS. Most studies are not directly applicable, particularly when considering the form, level, and averaging time of the standard. It is critical that each element of the NAAQS is fully considered, and it is inappropriate to isolate the pollutant level from a study without considering other elements of the NAAQS that a study does not directly address. Relating patterns and circumstances of exposure, and exposure measurements, from experimental and observational studies to all elements of the NAAQS can be challenging, but if US EPA did this, it would be evident that available studies do not indicate that a lower NAAQS level will be more health protective than the current one.

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Goodman *et al.* In Press.

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Goodman *et al.* In Press.

Table 1 History of the Ozone National Ambient Air Quality Standard

Year	Indicator	Averaging Time	Level (ppm)	Form
1971	total photochemical oxidants	1-hour	0.08	Not to be exceeded more than once per year
1979	ozone	1-hour	0.12	Not to be exceeded more than once per year
1997	ozone	8-hour	0.08	Annual fourth-highest daily max, averaged over 3 years
2008	ozone	8-hour	0.075	Annual fourth-highest daily max, averaged over 3 years

Levels are identical for primary and secondary ozone standards.
ppm = parts per million.
Adapted from http://www.epa.gov/ttn/naaqs/standards/ozone/s_o3_history.html

Goodman *et al.* In Press.

Study	Sample Size	Exposure	Ozone (ppm)
Adams (2006)	30	CH-TRI	0.04
Adams (2002)	30	FM-SQR	0.04
Kim *et al.* (2011)	59	CH-SQR	0.06
Adams (2006)	30	CH-TRI	0.06
Adams (2006)	30	CH-SQR	0.06
Schelegle *et al.* (2009)	31	CH-TRI	0.063
Schelegle *et al.* (2009)	31	CH-TRI	0.072
Adams (2006)	30	CH-SQR	0.08
Adams (2002)	30	FM-SQR	0.08
Adams (2006)	30	CH-TRI	0.08
Schelegle *et al.* (2009)	31	CH-TRI	0.081
Schelegle *et al.* (2009)	31	CH-TRI	0.088
Adams (2002)	30	FM-SQR	0.12
Adams (2002)	30	CH-SQR	0.12

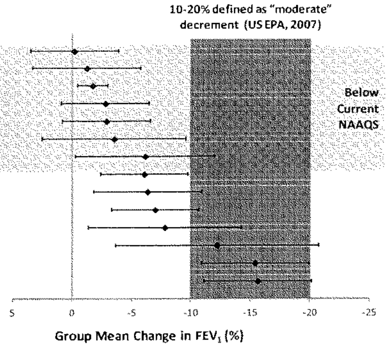

Figure 1. Ozone Exposure and Lung Function Decrements in Controlled Exposure Studies with Exposures below the Current Standard Level (0.075 ppm). CH=Chamber Exposure; FEV$_1$=Forced Expiratory Volume in One Second; FM=Face Mask Exposure; SQR=Square-wave Exposure Profile; TRI=Triangle Exposure Profile. Adapted from Goodman *et al.* (2013).

Goodman *et al.* In Press.

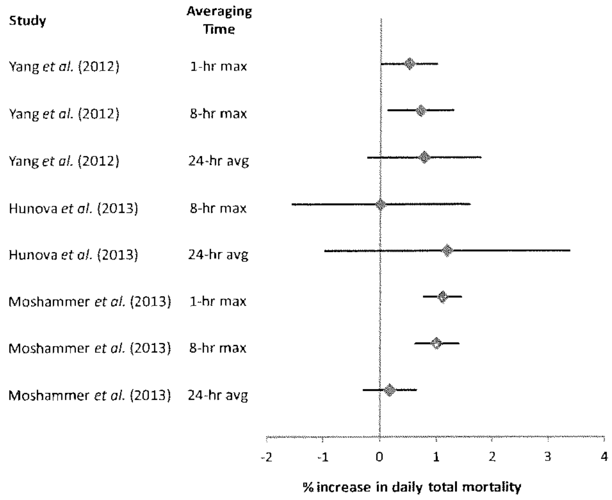

Figure 2. Ozone Exposure and Daily Mortality. Association between a 10 ppb-increase in 1-day lag ozone concentrations (measured as either 1-hr max, 8-hr average, or 24-hr average) and daily mortality in Suzhou, China (Yang *et al.*, 2012), Prague, Czech Republic (Hunova *et al.*, 2013), and Vienna, Austria (Moshammer *et al.*, 2013).

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September 2, 2011

Obama Administration Abandons Stricter Air-Quality Rules

By JOHN M. BRODER

WASHINGTON — President Obama abandoned a contentious new air pollution rule on Friday, buoying business interests that had lobbied heavily against it, angering environmentalists who called the move a betrayal and unnerving his own top environmental regulators.

The president rejected a proposed rule from the Environmental Protection Agency that would have significantly reduced emissions of smog-causing chemicals, saying that it would impose too severe a burden on industry and local governments at a time of economic distress.

Business groups and Republicans in Congress had complained that meeting the new standard, which governs emissions of so-called ground-level ozone, would cost billions of dollars and hundreds of thousands of jobs.

The White House announcement came barely an hour after another weak jobs report from the Labor Department and in the midst of an intensifying political debate over the impact of federal regulations on job creation that is already a major focus of the presidential campaign.

The president is planning a major address next week on new measures to stimulate employment. Republicans in Congress and on the campaign trail have harshly criticized a number of the administration's environmental and health regulations, which they say are depressing hiring and forcing the export of jobs.

The E.P.A., following the recommendation of its scientific advisers, had proposed lowering the so-called ozone standard of 75 parts per billion, set at the end of the Bush administration, to a stricter standard of 60 to 70 parts per billion. The change would have thrown hundreds of American counties out of compliance with the Clean Air Act and required a major enforcement effort by state and local officials, as well as new emissions controls at industries across the country.

The administration will try to follow the more lenient Bush administration standard set in 2008 until a scheduled reconsideration of acceptable pollution limits in 2013. Environmental advocates vowed on Friday to challenge that standard in court, saying it is too weak to protect public health adequately.

Ozone, when combined with other compounds to form smog, contributes to a variety of ailments, including heart problems, asthma and other lung disorders.

Lisa P. Jackson, the E.P.A. administrator, has pushed hard for a tougher ozone standard, telling associates that it was one of the most important regulatory initiatives she would handle during her tenure. But she found herself on the losing end of a fight with top White House economic and political advisers, who were persuaded by industry arguments that the 2008 ozone rule was due to be reviewed in two years anyway and who were concerned about the impact on state, local and tribal governments that would bear much of the burden of compliance.

The impact would have been felt heavily in a band of Midwest and Great Plains states that are not themselves major sources of ozone pollution and that will be critical 2012 electoral battlegrounds.

In a statement, the president reiterated his commitment to environmental concerns, but added: "At the same time, I have continued to underscore the importance of reducing regulatory burdens and regulatory uncertainty, particularly as our economy continues to recover. With that in mind, and after careful consideration, I have requested that Administrator Jackson withdraw the draft Ozone National Ambient Air Quality Standards at this time."

In words of reassurance directed at Ms. Jackson and the agency she heads, the president said that his commitment to the work of the agency was "unwavering."

"And my administration will continue to vigorously oppose efforts to weaken E.P.A.'s authority under the Clean Air Act or dismantle the progress we have made," he said.

Ms. Jackson accepted the White House decision with a terse statement: "We will revisit the ozone standard, in compliance with the Clean Air Act."

She pointed with pride to the administration's record of establishing a range of other air quality safeguards for power plants, manufacturing facilities and vehicles that will also help to reduce ozone pollution across the country.

Ms. Jackson had made clear her intention to follow her scientific advisers and set a new standard within the more restrictive range by the end of this year. She has told associates that her success in addressing this problem would be a reflection of her ability to perform her job. The agency sent the now-rejected standards to the White House in July with the expectation that they would be issued by Aug. 31.

While some senior agency officials expressed disappointment with the decision, they also said they understood that it was their job to offer their best technical advice to the White House and that the ultimate decision rested with the president, who has to stand for re-election and consider other factors.

Reaction from environmental advocates ranged from disappointment to fury, with several noting that in just the past month the administration had tentatively approved drilling in the Arctic, given an environmental green light to the 1,700-mile Keystone XL oil pipeline from Alberta, Canada, to Texas and opened 20 million more acres of the Gulf of Mexico to drilling.

Daniel J. Weiss, senior fellow at the Center for American Progress, said, "Today's announcement from the White House that they will retreat from implementing the much-needed — and long-overdue — ozone pollution standard is deeply disappointing and grants an item on Big Oil's wish list at the expense of the health of children, seniors and the infirm." The center is a liberal research group with close ties to the White House.

Bill McKibben, an activist leading a two-week White House protest against the pipeline project which has resulted in more than 1,000 arrests, said that the latest move was "flabbergasting."

"Somehow we need to get back the president we thought we elected in 2008," he said.

Cass R. Sunstein, who leads the White House office that reviews all major regulations, said he was carefully scrutinizing proposed rules across the government to ensure that they are cost efficient and based on the best current science. He said in a letter to Ms. Jackson that the studies on which the E.P.A.'s proposed rule is based were completed in 2006 and that new assessments were already under way.

The issue had become a flashpoint between the administration and Republicans in Congress, who held up the proposed ozone rule as a test of the White House's commitment to regulatory reform and job creation. Imposing the new rule before the 2012 election would have created political problems for the administration and for Democrats nationwide seeking election in a brittle economy.

Leaders of major business groups — including the U.S. Chamber of Commerce, the National Association of Manufacturers, the American Petroleum Institute and the Business Roundtable — met with Ms. Jackson and with top White House officials this summer seeking to moderate, delay or kill the rule. They told William M. Daley, the White House chief of staff, that the rule would be very costly to industry and would hurt Mr. Obama's chances for a second term.

John Engler, a former governor of Michigan and chairman of the Business Roundtable, said Friday in a statement: "Creating U.S. jobs and providing more economic certainty for all Americans, especially on the heels of today's news that the U.S. unemployment rate remains persistently high, is our greatest challenge. If President Obama's speech next week is as positive as this decision was today, it will be a success."

Representative Eric Cantor, the majority leader, said this week that the House would review the ozone rule, which he called the most onerous of all proposed regulations.

“This effective ban or restriction on construction and industrial growth for much of America is possibly the most harmful of all the currently anticipated Obama administration regulations,” Mr. Cantor wrote. He said that the impact would be felt across the economy and cost as much as $1 trillion and millions of jobs over the next decade.

Leslie Kaufman contributed reporting from New York.

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REVIEW ARTICLE

Critical considerations in evaluating scientific evidence of health effects of ambient ozone: a conference report

Roger O. McClellan[1], Mark W. Frampton[2], Petros Koutrakis[3], William F. McDonnell[4], Suresh Moolgavkar[5], D. Warner North[6], Anne E. Smith[7], Richard L. Smith[8], and Mark J. Utell[2]

[1]Toxicology and Human Health Risk Analysis, Albuquerque, New Mexico, USA, [2]University of Rochester Medical Center, Rochester, New York, USA, [3]Harvard University School of Public Health, Cambridge, Massachusetts, USA, [4]William F. McDonnell Consulting, Chapel Hill, North Carolina, USA, [5]Exponent, Inc., Bellevue, Washington, USA, [6]NorthWorks, Inc., Belmont, California, USA, [7]CRA International, Washington, DC, USA, and [8]University of North Carolina, Chapel Hill, North Carolina, USA

Abstract

The U.S. Environmental Protection Agency (EPA), under the authority of the Clean Air Act (CAA), is required to promulgate National Ambient Air Quality Standards (NAAQSs) for criteria air pollutants, including ozone. Each NAAQS includes a primary health-based standard and a secondary or welfare-based standard. This paper considers only the science used for revision of the primary standard for ozone in 2008. This paper summarizes deliberations of a small group of scientists who met in June 2007 to review the scientific information informing the EPA Administrator's proposed revision of the 1997 standard. The Panel recognized that there is no scientific methodology that, in the absence of judgment, can define the precise numerical level, related averaging time, and statistical form of the NAAQS. The selection of these elements of the NAAQS involves policy judgments that should be informed by scientific information and analyses. Thus, the Panel members did not feel it appropriate to offer either their individual or collective judgment on the specific numerical level of the NAAQS for ozone. The Panel deliberations focused on the scientific data available on the health effects of exposure to ambient concentrations of ozone, controlled ozone exposure studies with human volunteers, long-term epidemiological studies, time-series epidemiological studies, human panel studies, and toxicological investigations. The deliberations also dealt with the issue of background levels of ozone of nonanthropogenic origin and issues involved with conducting formal risk assessments of the health impacts of current and prospective levels of ambient ozone. The scientific issues that were central to the EPA Administrator's 2008 revision of the NAAQS for ozone will undoubtedly also be critical to the next review of the ozone standard. That review should begin very soon if it is to be completed within the 5-year cycle specified in the CAA. It is hoped that this Report will stimulate discussion of these scientific issues, conduct of additional research, and conduct of new analyses that will provide an improved scientific basis for the policy judgment that will have to be made by a future EPA Administrator in considering potential revision of the ozone standard.

Keywords: *Ozone, air quality, national ambient air quality standards, air pollution, respiratory effects, clean air act, risk assessment*

Contents

Abstract 1
Introduction 2
Clean Air Act Authority for Setting NAAQS 2
Historical Review of the NAAQS for Ozone 4
Framework for Evaluating Health Effects 5

This article is the report of a Working Conference held in Rochester, New York, USA, June 5–6, 2007. The authors are the conference participants.

Address for correspondence: Roger O. McClellan, Advisor, Toxicology and Human Health Risk Analysis, Albuquerque, NM 87111, USA. Fax: 505-296-9573; E-mail: roger.o.mcclellan@att.net

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Public Health Goal 5
Monitoring Data 5
Personal Exposure 6
Dosimetry of Inhaled Ozone 6
Conduct of Epidemiological Investigations 6
Overarching Issues 6
Policy Relevant Background 6
Variability and Uncertainty 7
Exposure Assessment 9
Evidence for Health Effects of Ozone 10
Long-Term Studies of Ozone and Mortality 10
Short-Term Morbidity and Mortality (Time-Series) Studies 13
Panel Studies 22
Controlled Human Exposure Studies 23
Mechanisms of Ozone Toxicity 26
Risk Assessment 27
The Risk Assessment Process 27
Uncertainty in Estimating Ambient Concentration-Response Relationships 28
Uncertainty in Estimating Changes in Ozone Exposures 29
Uncertainty Associated with EPA's Assumption on "Policy Relevant Background" 30
Need for Integrated Uncertainty Analysis 31
Summary 32
Acknowledgments 34
References 34

Introduction

This report summarizes the deliberations of the participants in a Working Conference to discuss key considerations in evaluating the scientific evidence on the health effects of ambient ozone that are germane to policy judgments on the setting of the National Ambient Air Quality Standard for ozone. The workshop was organized and participants invited by Mark J. Utell, Professor of Medicine, University of Rochester, with financial support and input from the American Petroleum Institute (API). Participants received copies of the key U.S. Environmental Protection Agency (EPA) documents and reprints of key papers prior to the meeting and identified additional reprints that were distributed to the Panel in advance of the meeting.

The workshop, held June 5–6, 2007 in Rochester, New York, took advantage of the small number of participants to hold discussions in a roundtable format, with individuals leading the conversation in their particular areas of interest. A representative from the API and another from the EPA served as valuable resources and provided clarifying information when requested by the participants of the Working Conference. The API and EPA representatives had no role in preparation or review of the report. Roger McClellan agreed to coordinate the preparation of a summary report based on written material submitted by the participants. All participants reviewed and commented on the entire report to help ensure its accuracy and clarity for a broad audience. However, readers of the report should recognize that although the individual participants are experts in one or more of the topics covered, no participant had an in-depth knowledge of all the areas covered. In areas as complex as those covered at the Conference and in this report, individual scientists may have differing views on interpretation of specific scientific issues. Moreover, individual scientists reviewing the same science may reach different judgments in applying the science in the standard-setting process. Thus, the participants did not attempt to forge a consensus on all scientific issues. Most importantly, the participants did not offer either individual judgments or a consensus judgment as to the numerical level of the National Ambient Air Quality Standard (NAAQS) for ozone. The participants agreed that although the science reviewed and discussed should inform the setting of the NAAQS for ozone, the selection of a specific numerical level, averaging time, and associated statistical form for the NAAQS was not a specific focus of the workshop and, most importantly, such policy judgments are ultimately the responsibility of the EPA Administrator as described in the next section.

Clean Air Act authority for setting NAAQS

Section 108 (42 U.S.C. § 7408) directs the Administrator to identify and list "air pollutants" that "in his judgment, may reasonably be anticipated to endanger public health and welfare" and whose "presence...in the ambient air results from numerous or diverse mobile or stationary sources" and to issue air quality criteria for those that are listed. Air quality criteria are intended to "accurately reflect the latest scientific knowledge useful in indicating the kind and extent of identifiable effects on public health or welfare which may be expected from the presence of [a] pollutant in ambient air....."

Section 109 (42 U.S.C. § 7409) directs the Administrator to propose and promulgate "primary" and "secondary" NAAQS for pollutants listed under section 108. Section 109(b)(1) defines a primary standard as one "the attainment and maintenance of which in the judgment of the Administrator, based on such criteria and allowing an adequate margin of safety, are requisite to protect the public health." The legislative history of § 109 indicates that a primary standard is to be set at "the maximum permissible ambient air level...which will protect the health of any [sensitive] group of the population," and that for this purpose "reference should be made to a representative sample of persons comprising the sensitive group rather than to a single person in such a group" (S. Rep. No. 91-1196, 91st Cong., 2d Sess. 10 (1970).

A secondary standard, as defined in § 109(b)(2), must "specify a level of air quality the attainment and maintenance of which, in the judgment of the Administrator, based on such criteria, is requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of [the] pollutant in the ambient air." Welfare effects as defined in § 302(h) (42 U.S.C. § 7602(h)) include, but are not limited to, "effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being." This report deals exclusively with the scientific issues involved in setting the primary (public health) standard and does not consider issues related to the setting of the secondary (welfare) standard.

The requirement that primary standards include an adequate margin of safety was intended to address uncertainties associated with inconclusive scientific and technical information available at the time of standard setting. It was also intended to provide a reasonable degree of protection against hazards that research has not yet identified. [*Lead Industries Association v. EPA*, 647 F.2d 1130, 1154 (D.C. Cir 1980), *cert. denied*, 449 U.S. 1042 (1980); *American Petroleum Institute v. Costle*, 665 F.2d 1176, 1186 (D.C. Cir. 1981), *cert. denied*, 455 U.S. 1034 (1982).] Both kinds of uncertainties are components of the risk associated with pollution at levels below those at which human health effects can be said to occur with reasonable scientific certainty. Thus, in selecting primary standards that include an adequate margin of safety, the Administrator is seeking not only to prevent pollution levels that have been demonstrated to be harmful but also to prevent lower pollutant levels that may pose an unacceptable risk of harm, even if the risk is not precisely identified as to nature or degree. The Clean Air Act does not require the Administrator to establish a primary NAAQS at a zero-risk level or at background concentration levels (*see Lead Industries Association v. EPA*, 647 F.2d at 1156 n.51), but rather at a level that reduces risk sufficiently so as to protect public health with an adequate margin of safety.

In addressing the requirement for an adequate margin of safety, EPA considers such factors as the nature and severity of the health effects, the size of the population(s) at risk, and the nature and degree of uncertainties that must be addressed. The selection of any particular approach to providing an adequate margin of safety is a policy choice left specifically to the Administrator's judgment. *Lead Industries Association v. EPA*, 647 F.2d at 1161-62; Whitman v. American Trucking Associations, 531 U.S. 457, 495 (2001) (Breyer, J., concurring in part and concurring in judgment).

In setting standards that are "requisite" to protect public health and welfare, as provided in section 109(b), EPA's task is to establish standards that are neither more or less stringent than necessary for these purposes (*Whitman v. American Trucking Associations*, 531 U.S. 457, 473). In establishing "requisite" primary and secondary standards, EPA may not consider the costs of implementing the standards (*Id.* at 471). As discussed by Justice Breyer in *Whitman v. American Trucking Associations*, however, "this interpretation of § 109 does not require the EPA to eliminate every health risk, however slight, at any economic cost, however great, to the point of "hurtling" industry over "the brink of ruin," or even forcing "deindustrialization." (*Id.* at 494) (Breyer, J., concurring in part and concurring in judgment) (*citations omitted*). Rather, as Justice Breyer explained:

> *"The statute, by its express terms, does not compel the elimination of all risk; and it grants the Administrator sufficient flexibility to avoid setting ambient air quality standards ruinous to industry.*
> *Section 109(b)(1) directs the Administrator to set standards that are "requisite to protect the public health" with "an adequate margin of safety." But these words do not describe a world that is free of all risk—an impossible and undesirable objective. (citation omitted). Nor are the words "requisite" and "public health" to be understood independent of context. We consider football equipment "safe" even if its use entails a level of risk that would make drinking water "unsafe" for consumption. And what counts as "requisite" to protecting the public health will similarly vary with background circumstances, such as the public's ordinary tolerance of the particular health risk in the particular context at issue. The Administrator can consider such background circumstances when "deciding what risks are acceptable in the world in which we live." (citation omitted).*
>
> *The statute also permits the Administrator to take account of comparative health risks. That is to say, she may consider whether a proposed rule promotes safety overall. A rule likely to cause more harm to health than it prevents is not a rule that is "requisite to protect the public health." For example, as the Court of Appeals held and the parties do not contest, the Administrator has the authority to determine to what extent possible health risks stemming from reductions in tropospheric ozone (which, it is claimed, helps prevent cataracts and skin cancer) should be taken*

> *into account in setting the ambient air quality standard for ozone. (Citation omitted).*
>
> *The statute ultimately specifies that the standard set must be "requisite to protect the public health" "in the judgment of the Administrator," § 109(b)(1), 84 Stat. 1680 (emphasis added), a phrase that grants the Administrator considerable discretionary standard-setting authority.*
>
> *The statute's words, then, authorize the Administrator to consider the severity of a pollutant's potential adverse health effects, the number of those likely to be affected, the distribution of the adverse effects, and the uncertainties surrounding each estimate. (citation omitted). They permit the Administrator to take account of comparative health consequences. They allow her to take account of context when determining the acceptability of small risks to health. And they give her considerable discretion when she does so.*
>
> *This discretion would seem sufficient to avoid the extreme results that some of the industry parties fear. After all, the EPA, in setting standards that "protect the public health" with "an adequate margin of safety," retains discretionary authority to avoid regulating risks that it reasonably concludes are trivial in context. Nor need regulation lead to deindustrialization. Pre-industrial society was not a very healthy society; hence a standard demanding the return of the Stone Age would not prove "requisite to protect the public health."*
>
> *Although I rely more heavily than does the Court upon legislative history and alternative sources of statutory flexibility, I reach the same ultimate conclusion. Section 109 does not delegate to the EPA authority to base the national ambient air quality standards, in whole or in part, upon the economic costs of compliance."*

Section 109(d)(1) of the Clean Air Act requires that "not later than December 31, 1980, and at 5-year intervals thereafter, the Administrator shall complete a thorough review of the criteria published under section 108 and the national ambient air quality standards... and shall make such revisions in such criteria and standards and promulgate such new standards as may be appropriate...." Section 109(d)(2) requires that an independent scientific review committee "shall complete a review of the criteria...and the national primary and secondary ambient air quality standards...and shall recommend to the Administrator any new...standards and revisions of existing criteria and standards as may be appropriate..." This independent review function is performed by the Clean Air Scientific Advisory Committee (CASAC) of EPA's Science Advisory Board.

Historical review of the NAAQS for ozone

Each NAAQS consists of four elements: an indicator, an averaging time, a numerical level, and a statistical form. The initial NAAQS for photochemical oxidants was promulgated on April 30, 1971, with both the primary and secondary standard set at 0.08 ppm, total photochemical oxidants, not to be exceeded more than 1 h per year. On February 8, 1977, the NAAQS for photochemical oxidants was revised. The indicator was changed to ozone, and the associated analytical method changed, with the level of both the primary and secondary standard set at 0.12 ppm ozone for a 1-h averaging time. The form of the standard was also changed to one based on the expected number of days per calendar year with a maximum hourly average concentration above 0.12 ppm (i.e., attainment of the standard occurs when that number is equal to or less than 1). On July 18, 1997, the ozone NAAQS was revised with the averaging time changed from 1 to 8 h and the numerical level set at 0.08 ppm, which may be viewed as equivalent to 0.084 ppm using the standard rounding convention. The form of the standard was changed to the annual fourth-highest daily maximum 8-h average concentration, averaged over 3 years. Without going into the details, provision was made for an orderly transition from the 1-h averaging time to an 8-h averaging time. It is obvious that 1-h averaging time values exceed 8-h averaging time ozone values, which in turn exceed 24-h averaging time ozone values. The relationship between the three averaging time values varies day to day, throughout the year, and among different communities. In 1996–1997, it was viewed on average that a 0.12-ppm, 1-h averaging time value, was approximately equivalent to 0.09 ppm ozone averaged over 8 h. Thus, the 1997 NAAQS of 0.08 ppm averaged over 8 h was expected to he somewhat more restrictive than the previous 1-h averaging time NAAQS set at 0.12 ppm ozone. The 1997 revision of the NAAQS for ozone was based on the EPA Criteria Document (1996a) and Staff Paper (1996b).

The EPA initiated, in September 2000, the review completed in March 2008 with a call for information for the development of a revised Air Quality Criteria Document for ozone and other photochemical oxidants. The EPA, under a court decree, after several extensions, was required to complete its review of the scientific criteria for ambient ozone limits and sign the publication notices of proposal and final rule making of the ozone NAAQS by June 20, 2007, and March 12, 2008, respectively. To meet this schedule, the EPA prepared a new Criteria Document (2006) and Staff Paper (2007a). The Staff Paper was supported by an ozone population exposure analysis for selected urban areas (EPA, 2007b), an analysis of uncertainties in the exposure analysis (EPA, 2007c) and a detailed ozone health risk assessment for selected urban areas (EPA, 2007d).

The Administrator met the June 20, 2007, deadline for the proposed rule making with the Proposed Rule published in the July 11, 2007 Federal Register (EPA, 2007e). In summary, "The Administrator's proposed decision is to revise the existing 8-h ozone primary standard by lowering the level to within a range from 0.070 to 0.075 ppm, and to specify the standard to the nearest thousandths ppm (i.e., to the nearest parts per "billion"). In the Proposed Rule, "the EPA solicits comments on alternative levels down to 0.060 ppm and up to and including retaining the current 8-h standard of 0.08 ppm (effectively 0.084 ppm using current data rounding conventions)." The EPA's proposed rule was based on consideration of evidence of ozone health effects from controlled human exposure, epidemiological and toxicological studies. In this report, each of these kinds of evidence is discussed and critiqued. By way of background, the EPA also prepares an additional document, a Regulatory Impact Analysis, to support the development of air pollution regulations. That report (EPA, 2007f) was released on August 2, 2007. The report is not part of the standard selection process. It is intended to inform the public and States about the potential costs and benefits of implementing the proposed air quality standards. The Panel did not review that report. However, it is obvious that many of the issues discussed in this report, especially those addressing risk assessment issues, are also relevant to the preparation and interpretation of the Regulatory Impact Analysis.

EPA Administrator Stephen Johnson announced the Final Rule for the National Ambient Air Quality Standard for ozone on March 12, 2008, and the Final Rule was published in the March 27, 2008, Federal Register (EPA, 2008). The NAAQS for ozone was revised with the primary standard set at 0.075 ppm for an 8-h averaging time. The statistical form of the standard was not changed, namely, the revised 8-h primary standard of 0.075 ppm will be met at an ambient monitoring site when the 3-year average of the annual four highest daily maximum 8-h average O_3 concentration is less than or equal to 0.075 ppm.

Framework for evaluating health effects

The general framework used for integrating scientific information on ambient air pollutants and their health effects is shown in Figure 1. This framework has been widely used in evaluating the health risks of airborne materials and provided the basis for the deliberations and recommendations in the four reports of the National Research Council (NRC) Committee on "Research Priorities for Airborne Particulate Matter" (NRC, 1998, 1999, 2001, 2003). We refer to it here to make several overarching points.

Public health goal

It is important to emphasize that explicit in the Clean Air Act is the intent to regulate air pollutants, such as the criteria air pollutants including ozone, to manage health impacts of air pollution to acceptable risk levels. This is accomplished in a multistep process. The first is to establish NAAQS for specific pollutants such as ozone In a second step, measures are taken to limit the man-made emissions of the pollutant or its precursors to achieve ambient air concentrations compliant with the appropriate NAAQS.

Ozone is formed in the troposphere from precursors that are of both biogenic and anthropogenic origins. Thus, even in the absence of man-made (anthropogenic) emissions of ozone precursors, there are ambient concentrations of ozone from biogenic precursors, lightning, and periodic intrusions of stratospheric ozone into the troposphere. To assist in considering the portion of the ambient ozone of natural origin, and, thus, not readily controllable, the EPA has introduced the concept of "Policy Relevant Background" ozone. It is defined "as the ozone concentrations that would be observed in the U.S. in the absence of anthropogenic emissions of precursors (e.g., VOC, NO_2 and CO) in the U.S., Canada and Mexico." The issue of Policy Relevant Background ozone is of sufficient importance that it will be discussed in a separate section of this paper.

Monitoring data

Substantial monitoring data on regulated pollutants are routinely collected in locales across the United States, primarily to demonstrate compliance with the NAAQS for the individual air pollutants. Other pollutants are monitored much less frequently and typically on a "campaign" basis rather than the year-after-year, decade-after-decade approach taken with the Criteria Pollutants. Ozone levels have generally been decreasing in most communities across the United States as a result of air quality control measures, with an estimated 21% reduction (8-h maximum average) and a 29%

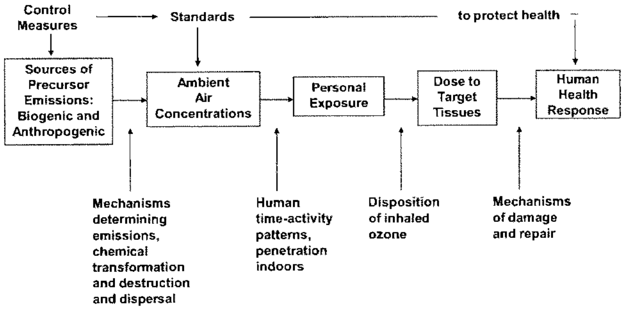
Control Measures
Standards
to protect health
Sources of Precursor Emissions: Biogenic and Anthropogenic
Ambient Air Concentrations
Personal Exposure
Dose to Target Tissues
Human Health Response
Mechanisms determining emissions, chemical transformation and destruction and dispersal
Human time-activity patterns, penetration indoors
Disposition of inhaled ozone
Mechanisms of damage and repair

Figure 1. Framework for evaluating health risks of ozone.

reduction (1-h maximum average) in ambient ozone nationwide since 1980 (EPA, 2007g).

Significant progress has also been made in reducing ambient concentrations of other criteria pollutants. In addition to evaluating compliance with the NAAQS, the routine monitoring data have also been used extensively as indices of exposure in epidemiological studies in which the air quality data are most frequently used in combination with data on morbidity and mortality of populations obtained from administrative databases.

Personal exposure

It is obvious that individuals breathe whatever is in the air in their personal breathing zone. The concentration of ozone measured at monitoring stations is an imperfect surrogate for the ozone concentration at other locations. The correlation between ambient monitor concentrations and that found in the interiors of homes, offices, other workplaces, and other buildings is poor because of the high reactivity of ozone deposition on surfaces, and the influence of building ventilation. As discussed in a later section, some studies have attempted to characterize the actual exposure of individuals. Those kinds of exposure data are valuable for studying small groups of individuals. However, it is not feasible to acquire personal exposure data on large populations of individuals over long periods of time.

Dosimetry of inhaled ozone

Substantial knowledge has been acquired of the relationship between quantities of ozone inhaled and the deposition of ozone in the respiratory tract of humans and some laboratory animal species. This information is of special value in understanding how inhaled ozone affects the body. Moreover, it is useful in understanding how toxicological data acquired in laboratory animal species may be extrapolated to humans, recognizing critical species differences in ozone dosimetry.

Conduct of epidemiological investigations

Epidemiological investigations provide highly relevant evidence as to whether ambient environmental factors, such as air pollutants, including ozone, can adversely affect the health of the general public. These studies are especially valuable because they consider the real-world experiences of people as they are exposed to air pollution in the course of their daily lives. The majority of the studies of ozone exposure have been observational semiecological studies that analyze aggregate ambient concentration data as a surrogate for exposure for large groups of people. The studies seek to evaluate whether a statistical association exists between ambient ozone concentrations and a health outcome. By assuming that ambient concentrations are correlated with exposures, and exposures are correlated with personal doses, epidemiological studies attempt to link ambient ozone and health outcomes shown in Figure 1. Ozone concentrations measured at one or a few central monitors are used as an index of exposure. As noted earlier, the monitoring data are typically required for regulatory compliance purpose; their use in epidemiological studies is a fringe benefit. The monitors are rarely located with special attention given to the location as being representative of a specific population. The ozone data may be available from daily measurements made year round or only in the summer when ozone concentrations are generally higher. They may be aggregated as a daily 24-h average, the highest 8-h average or the maximum 1-h concentration. The latter two indices reflect past NAAQSs for ozone that used 8-h or 1-h averaging times. At many monitoring stations, data are acquired on other criteria pollutants, temperature, and relative humidity. Various health indices, such as measures of morbidity or mortality, are evaluated for their association with ambient ozone concentration. The result may be expressed as a proportional increase or decrease in the health index per increment of ozone concentration. None of the health effects evaluated are unique to ozone. Exposure to other pollutants, temperature, relative humidity, other indicators of weather, as well as population characteristics such as age, health status, socioeconomic status, housing, and exercise also influence the various health effects. The role of ozone must be statistically separated from these other health determinants, which presents the most difficult challenge in epidemiological studies of this sort.

Overarching issues

Policy Relevant Background

The issue of defining and then characterizing the background concentrations of ozone is of critical importance for several reasons to any potential revision of the NAAQS for ozone. The definition used for background ozone will determine the relevant background ambient ozone concentrations. In this NAAQS ozone review, the EPA has coined the term, Policy Relevant Background (PRB) of ozone. This is defined as the ozone concentrations that would be observed in the United States in the absence of anthropogenic emissions of precursors (e.g., VOC, NO_2, and CO) in the United States, Canada, and Mexico. Indeed, the Policy Relevant Background values used in the Staff Paper and Risk Assessment were set by "turning off the inputs for man-made precursors of ozone" in a low-resolution chemical transport model (GEOS-CHEM) (Fiore et al., 2002, 2003). The GEOS-CHEM model has very low spatial resolution (2 degrees by 2.5 degrees). This corresponds to 138 miles by 173 miles with an area of 24,000 square miles, an area about half that of the Commonwealth of Pennsylvania.

It is especially significant that the manner in which the model was used zeros out all Canadian and Mexican man-made emissions of ozone precursors. As a result, the Policy Relevant Background estimates the EPA uses overstate the levels of ozone that U.S. regulations can potentially control. An alternative definition of Policy Relevant Background for ozone would be the background ambient concentrations of ozone projected for the United States in the absence of emissions of man-made precursors of ozone in the United States. Using this definition would allow characterization of the concentrations of ozone attributable to man-made precursors by the difference between measured or modeled ambient ozone concentrations and the estimated background concentrations of ozone. This would be the portion of ambient ozone that could be influenced by U.S. regulations and the actions of the regulated sources of ozone precursors.

Getting the background ambient concentrations of ozone correct across the United States is vitally important to understanding how the background concentration of ozone will influence the likelihood that communities will attain any particular NAAQS for ozone. Since 1997, the NAAQS for ozone has had an averaging time of 8h and an associated statistical form. Thus, it is necessary to characterize the distribution of each hour's ozone PRB over multiple days to capture the variability in PRB and not just a typical or "average" level in order to determine how the background levels of ozone will influence the attainment of the 8-h averaging time. With a robust statistical form used to define attainment of the 8-h averaging time standard, infrequent high levels of background ozone may keep many communities from attaining the standard, despite stringent limits on the emissions of man-made precursors of ozone. The lower the numerical level of the 8-h averaging time standard, the higher the likelihood that background levels of ozone will influence whether the community is in or out of attainment. This likelihood cannot be captured in modeled estimates of PRB that do not adequately reflect its day-to-day variability and spatial variability.

How background concentrations of ozone are defined and characterized has a major influence on the results of the risk assessment for current levels of ozone and various potential levels of NAAQS for ozone and the interpretation of these results. By assuming what are likely to be unrealistically low estimates of background ozone, the EPA has calculated risks at low ambient ozone concentrations that are not controllable with U.S. regulations and, further, treated these calculated risks as though they were attributable to ozone arising from man-made sources in the United States.

The EPA, in its proposed rule for ozone, acknowledged the shortcoming of the treatment of "Policy Relevant Background" in the Staff Paper, the Risk Assessment, and the Proposed Rule by noting in footnote 40 to the Proposed Rule that it will perform further analyses on this issue (EPA, 2007f). A good starting point for such analyses would be to include in a future Criteria Document and Staff Paper alternative approaches to considering background concentrations of ozone. Papers on ozone background levels that deserve careful consideration include those of Vingarzan (2004) and Oltmans et al. (2006). The importance of the issue of background levels of ozone is such that any revised information developed on this issue should be open for public review and comment. It is vitally important to recognize that choices made in estimating background ozone levels will necessitate changes in the risk assessment for ozone as regards the portion of estimated risk that may be attributed to background levels of ozone versus that attributed to man-made sources.

Variability and uncertainty

The topics of uncertainty and variability in the context of environmental risk assessment and regulatory decision making have been discussed at length in many reports of the National Research Council (NRC, 1983, 1993, 1994, 2002, 2007a, 2007b) prepared over the past 25 years. This section briefly summarizes definitions and main themes. For more extensive discussion the reader is referred to these National Academies reports and the multitude of references they contain.

The basic problem is a lack of data and a lack of scientific understanding and predictability of the impact of regulation on improving human health and the environment. In the transmittal letter for the seminal 1983 NRC report (NRC, 1983, page iii), National Academy of Science President Frank Press stated, "... the committee finds that the basic problem in risk assessment is the incompleteness of data ... ." The Summary of that report provides an expanded version of this statement by the authoring Committee: "The Committee believes that the basic problem in risk assessment is the sparseness and uncertainty of the scientific knowledge of the health hazards addressed, and this problem has no ready solution" (NRC, 1983, page 6). This theme is reiterated in the 1994 report, citing statements from the 1983 report similar to the two quotations above (NRC, 1994, page 160).

Uncertainty

"Uncertainty can be defined as a lack of precise knowledge as to what the truth is, whether qualitative or quantitative. That lack of knowledge creates an intellectual problem—that we do not know what 'scientific truth' is; and a practical problem—we need to determine how to assess and deal with risk in the light of that uncertainty" (NRC, 1994, page 161). "Scientific truth is always somewhat uncertain and is subject to revision as new understanding develops, but uncertainty in quantitative health risk assessment might be uniquely large, relative to other science policy areas, and it requires special attention by risk analysts." (Ibid. See also the Summary [NRC, 1994, pages 11-12]). In the context of this document, uncertainty refers to lack of knowledge on the human health impacts of changes in exposure to ozone and associated air pollutants for which monitored ozone concentrations may be an indicator. Uncertainty may also refer to lack of knowledge in the relation of ambient ozone levels to precursor emissions.

Variability

Variability may be defined as a description of differences among a population or a set of situations that one can describe in applying classical statistical methods to describing these differences. Variation in people's weight provides a simple example. A distribution of weights of adult males in the United States population describes the probability that the weight of an adult male chosen at random, among all those in the United States, will fall within given intervals from the lightest to the heaviest. For example, the probability of a weight of 150 to 155 pounds might be given as 4.1%, signifying that 4.1% of American adult males fall within this interval and that 95.9% weigh less than 150 or more than 155 pounds. If a subpopulation is selected, such as adult males from 60 up to 65 years of age, then this probability may change. Now only a subset of the data on weight of adult males, those aged 60–64, rather than all males at least 21 years of age, are used for the distribution.

A more complex example is susceptibility to health impact, such as a change in lung function measurement (such as forced expiratory volume at 1 second [FEV_1]) or in recorded symptoms, such as pain on deep inspiration resulting from exposure while exercising to ozone for a specific length of time and at a specific concentration. This is not a situation brought about by lack of data, but rather that the available data indicate that individuals differ in their response to an air pollutant such as ozone. For example, the subset of people who have been diagnosed with asthma may differ from those who have not been so diagnosed in their response to ozone. Similarly, because of differences in meteorological conditions and other factors, there is a great deal of variability how reductions in emissions of ozone precursors affect the ozone concentration levels that different individuals with differing exercise patterns in different locations experience. A detailed statistical description of ozone exposure over time to a population of individuals in different locations in a major city can become quite complex, even if all the relationships involved were known.

Both NRC Reports (NRC, 1983, 1994) urge EPA to improve its characterization of uncertainty in risk assessments, and to disaggregate and justify its assumptions in dealing with uncertainty (limitations in scientific knowledge and lack of data) and in variability among individual humans and exposure situations. Both uncertainty and variability can be treated using modern statistical methods, which include the use of expert judgment and inference methods to develop probability distributions in the absence of data. (Good recent reviews on uncertainty in risk assessment are found in NRC [2007a], pages 79–88, and NRC [2007b], pages 43–52.)

Effective communication about uncertainty and variability is needed to inform regulatory decision makers and the public. All of the National Research Council Reports (NRC, 1983, 1993, 1994, 2002, 2007a, 2007b) suggest that quantitative risk assessments can be helpful in achieving such effective communication. EPA needs to improve its practices in carrying out and communicating the results from risk assessments. "To the extent that both uncertainty and inter-individual variability (that is, heterogeneity or differences among people at risk) are addressed quantitatively with separate input components (e.g., ambient concentrations, uptake, and potency) for aggregation into an assessment of risk, the distinction between uncertainty and variability ought to be maintained rigorously throughout the analytic process, so that uncertainty and variability can be distinctly reflected in calculated risk" (NRC, 1994, page 239; see also the two summary points on page 242).

Because of the multitude of factors involving uncertainty, variability, and often both, simplifying assumptions are made to carry out risk assessments. Such assumptions typically involve value judgments, and such judgments are often made so as to be conservative in the protection of human health. For example, health effects might be computed assuming exposure at a location estimated to have the largest cumulative exposure over time to a toxic air contaminant. Health effects for such a hypothetical "maximally exposed individual" (MEI) should be greater than for people who are at other locations, and even for people who may spend some time at the point of maximum exposure but not all of their time. The analysis using an MEI is greatly simplified from that of calculating a distribution of time-varying exposures and consequent estimated health impacts. As described in NRC (NRC, 1994), especially Chapter 10, simplified analysis may be appropriate for screening calculations that investigate whether potential health impacts are large enough to warrant further investigation and regulatory decision making. For important assessments of health impacts, such as those for ozone, EPA appropriately uses much more complex analytical methods for describing exposures over time and by location, but these still require significant amounts of simplifying policy judgments.

Simplifying policy judgments that deal with uncertainty and variability are referred to in NRC Report (1994) as "inference guidelines" and in NRC Report (1994) as "defaults." Such judgments are needed for risk assessments, because without such simplification, analysis of most situations involving exposure to pollutants becomes impractically complicated. Therefore, sensitivity analysis and judgment are used to determine where uncertainty and variability should be explicitly addressed. Both NRC Reports (1983, 1994) urge a clarification in EPA practices through the use of guidelines and specific criteria for the use of defaults, or for departure from a default when justified by newly available scientific information. Appendices N-1 and N-2 of NRC (NRC, 1994) present contrasting viewpoints on appropriate criteria for selection of defaults and departure from defaults. Although the details are complex, both of these appendices and the main report of NRC (NRC, 1994) urge EPA to improve its use of quantitative analysis and resulting characterization of uncertainty and variability, for regulatory decision makers and for the public.

The 2002 NRC report (2002) addressed the specific problem of estimating public health benefits from regulation of emission precursors to pollutants such as ozone and fine particulate matter through NAAQS. The report describes concerns that estimates of morbidity and mortality—"body counts"—are being used in regulatory impact analysis without sufficient use of probabilistic methods to describe uncertainty and variability. "EPA should begin to move the assessment of uncertainties from its ancillary analyses into its primary analyses by conducting probabilistic, multiple-source uncertainty analysis. This shift will require specification of probability distributions for major sources of uncertainty. These distributions should be based on available data and expert judgment" (NRC, 2002, page 14). (Further discussion is found on pages 125–152.). "Although the results of benefit analysis may appear to be less certain, EPA should describe the uncertainty as completely and realistically as possible, recognizing that regulatory action might be necessary in the presence of substantial uncertainty" (NRC, 2002, page 15). "... uncertainties in each stage of the analysis should be quantified and carried through the entire [health benefits analysis] process" (NRC, 2002, page 153).

EPA has not, to date, incorporated uncertainty analysis into its primary risk analyses and we find that the overall interpretation of the risk analysis for ozone is potentially misleading as a result. Considerable uncertainty remains on the impact of reducing the 8-h ozone standard from the current level of 0.08 ppm to a lower level. EPA has assumed for its analysis that shifts in the probability distribution of exposure to ozone will occur not just in the upper tail of the distribution (the days on which ozone levels will exceed the existing 8-h standard of 0.08 ppm or proposed alternative standards of 0.060–0.074 ppm), but also the lower and middle portions of this distribution, levels below 0.060 ppm. It is these changes in the lower and middle portions of the distribution that provide most of the calculated benefits in terms of reduced short term-mortality and reduced hospital admissions associated with the more stringent alternative proposed standard. These matters are discussed in more detail later when the risk assessment process is discussed.

Exposure assessment

Personal exposures and indoor concentrations

Quite a few panel studies found that ozone personal exposures were substantially lower than ozone outdoor concentrations. These exposure assessment studies were conducted in a variety of environments, including Toronto (Liu et al., 1995); Vancouver (Brauer et al., 1995); Baltimore (Sarnat et al., 2000); Southern California (Geyh et al., 2000); Nashville (Lee et al., 2004); Mexico City (O'Neill et al., 2003); Boston (Koutrakis et al., 2005); and Steubenville (Sarnat et al., 2006). The low ozone personal exposures found in these panel studies are due to the high proportion of time spent indoors by study participants and the high deposition rate of ozone onto the microenvironmental surfaces. For example, Liu et al. (1995) and Brauer and Brook (1995) showed that subjects who spend more time outdoors were exposed to higher ozone levels.

Indoor concentrations of ozone are typically considerably lower than those measured outdoors, with indoor/outdoor ratios depending to a great extent on home ventilation. For homes with low air exchange rates, for example homes using air conditioning, indoor/outdoor ratios are very low. Consequently, in cities with hot summers, only a small fraction of ambient ozone can be found indoors.

In Nashville, Tennessee, summer indoor ozone concentrations ranged from 3% to 15% of outdoor concentrations with an average indoor/outdoor ratio of 0.10 (Lee et al., 2004). This ratio was lower than that (0.30) measured for two communities during the summer in Southern California (Geyh et al,. 2000). Indoor ozone concentrations are very low during the winter season because homes are tight, especially in cities with harsh winters where home air ventilation rates are lower than one air exchange per hour. Liu et al. (1995) measured indoor ozone concentrations in 50 homes in Toronto, Canada, and found that the average indoor/outdoor ratio was 0.11. A similar ratio was reported by Geyh et al. (2000) in the winter Southern California study. So even in locations without harsh winters, tight homes during this season can result in quite low indoor/outdoor ratios. Romieu et al. (1998) reported home indoor ozone concentrations in Mexico City that were 10%–30% of ambient concentrations with higher indoor concentrations in homes with windows open during the day. Indoor/outdoor ratios in schools, where windows and doors were frequently open, ranged between 0.3 and 0.4 and were higher than those observed homes, which were about 0.2 (1998).

Relationships between ozone personal exposures and outdoor concentrations

In the Baltimore (Sarnat et al., 2000) and Boston (Barnett et al., 2005) studies, ozone personal exposures were weakly correlated with ozone ambient concentrations. When personal exposures were regressed on ambient concentrations using mixed models, the estimated slopes were substantially lower than unity. In Baltimore, the estimated slopes for the winter and summer seasons were 0.00 (CI: –0.02, 0.02) and 0.04 (CI: –0.02, 0.10), respectively, which were not statistically significant. In Boston, the slopes were 0.05 (CI: 0.02, 0.08) for winter (nonsignificant) and 0.27 (CI: 0.13, 0.39) for summer (significant). Sarnat et al. (2006), for a panel study of elderly individuals in Steubenville, Ohio, found personal exposures were correlated with outdoor concentrations, but indoor ozone concentrations were substantially lower than ozone outdoor concentrations.

Somewhat different findings were reported by O'Neill et al. (2006) who measured exposures of outdoor workers (shoe cleaners) in Mexico City. In this study, strong within-worker longitudinal associations between ambient ozone concentrations and personal exposures were observed. The difference in ambient-personal relationships in this study compared to those presented above, likely relates to the substantial differences in time spent outdoors. This finding suggests that fixed-site ozone monitors may adequately estimate exposures in repeated-measure health studies of outdoor workers.

Relationships between personal $PM_{2.5}$ exposures and outdoor ozone concentration

During the summer season, when outdoor ozone and $PM_{2.5}$ concentrations are correlated, outdoor ozone concentrations may be surrogates for personal $PM_{2.5}$ exposures. This is supported by the Boston, Baltimore, and Steubenville summer panel studies of Koutrakis et al. (2005) and Sarnat et al. (2006). In contrast, the Boston and Baltimore winter panel studies and the Steubenville fall panel study did not show associations between personal $PM_{2.5}$ exposures and outdoor ozone levels. This is because outdoor ozone and $PM_{2.5}$ concentrations were inversely correlated, which is typical for northeastern urban environments during these seasons.

Exposure assessment implications for health effects studies

Panel studies. A number of panel health effects studies have examined associations between respiratory morbidity and ozone exposures. Except for a few studies, including Delfino et al. (1997) and Brauer et al. (1996), the majority of these panel investigations have relied on ambient monitors to estimate human exposures. Considering that several panel exposure studies have shown substantial inter- and intrapersonal variability in personal exposure/ambient concentration ratios, reliance on ambient monitors, especially for large geographic areas and for populations that do not spend a high proportion of the study period outdoors, may be inadequate and can introduce considerable bias. The impact of this exposure error is more severe on panel studies that examine a relatively small number of subjects as compared to that for population studies.

Time-series analyses. In cities with mild summers and/or winters, positive associations were found between ozone exposures and outdoor concentrations. In contrast, for cities with very hot summers and/or harsh winters, population ozone exposures may not be associated with the corresponding ambient concentrations, thus it is difficult to study the effects of ambient ozone. Furthermore, when interpreting the results of the ozone time-series health studies, it is important to keep in mind that during the summer outdoor ozone can be a surrogate of personal $PM_{2.5}$ or other pollutant exposures. Consequently, it may not be possible to distinguish between the health effects of ozone and those of fine particles or other pollutants when using ambient measurements of ozone during the summer season.

Multi-city studies. The extent of exposure error depends on the climatic conditions, and is more pronounced for populations living in cities with very hot summers (e.g., Baltimore and Nashville) and harsh winters (e.g., Toronto and Boston). Therefore, future exposure assessment studies should determine city specific population exposure/ambient concentrations ratios.

CASAC raised issue of exposure error. The importance of exposure error was presented in a letter of the CASAC ozone panel to the EPA Administrator, dated June 05, 2006. Below we present some excerpts regarding ozone exposure assessment issues:

> "The Ozone Staff Paper should consider the problem of exposure measurement error in ozone mortality time-series studies. It is known that personal exposure to ozone is not reflected adequately, and sometimes not at all, by ozone concentrations measured at central monitoring sites. Typically, personal exposures are much lower than the ambient concentrations, and can be dramatically lower depending on the time-activity patterns, housing characteristics and season. In addition, and of particular importance for the ozone time-series studies, there can be no correlation between personal concentrations of ozone measured over time and concentrations measured at central outdoor sites. The population that would be expected to be potentially susceptible to dying from exposure to ozone is likely to have ozone exposures that are at the lower end of the ozone population exposure distribution, in which case this population would be exposed to be very low concentration of ozone indeed, and especially so in winter. Therefore, it seems unlikely that the observed associations between short-term ozone concentrations and daily mortality are due solely to ozone itself."
>
> "Another implication of the ozone measurement error that is relevant in the ozone NAAQS-setting process is that the degree of measurement error would be expected to have a substantial impact on the ability to detect a threshold of the concentration-response relationship below which no ozone effects are discernable. Pollutant exposure measurement error obscures true thresholds in the concentration-response relationship, and this effect worsens with increasing degrees of measurement error. Since threshold assumptions are incorporated in the Agency's risk assessment and risk analyses, this issue will need to be addressed."
>
> "At least two questions arise from these observations that are relevant to the ozone NAAQS-setting process: (1) What chemical agent or agents are at least partly responsible for the observed associations between ozone and mortality in the time-series studies? and (2) Do we require an immediate answer to the question of whether ambient ozone adequately serves as a surrogate marker, that, when controlled, effectively mitigates health impacts of this entire mix of pollutants? One possible explanation for the observed associations of ozone is that ozone itself serves as a marker for other agents that are contributing to the short-term exposure effects on mortality. This would require that outdoor concentrations of these agents are correlated over time with outdoor ozone concentrations, which is to be expected if they are products of the same process that lead to ozone formation, and that these outdoor pollutant concentrations are better correlated with personal exposures than is the case for ozone itself."

We strongly agree with the exposure error issues raised by the CASAC panel, which are based on a thorough review of the ozone exposure assessment literature. These issues should be kept in mind when interpreting the results of ozone health effects studies and, thus, when setting air quality standards.

Evidence for health effects of ozone

Long-term studies of ozone and mortality

Although most epidemiological studies of air pollution are time series, a few mortality studies have followed cohorts of individuals in an attempt to investigate the association between air pollution and mortality (Table 1). Although these studies have been called cohort studies, they really adopt a design that is a hybrid of cohort and ecologic designs. In these studies, cohorts of individuals from different cities are followed in time and deaths in the cohorts are recorded.

Table 1. Major long-term studies considering ozone*.

Reference	Location, period	Design, methods	Ozone concentrations	Results reported	Remarks
Krewski et al., 2000	151 metropolitan areas in the US. Individual subjects followed up for variable periods of time. Extension of the Harvard six cities and ACS II studies.	'Hybrid' design, i.e., some covariates were known on individual level, others, in particular air pollution, measured on the city level. Thus study is hybrid of cohort and ecologic designs. Cox proportional hazards and extensions used for analyses.	Average daily 1-h concentrations of ozone used in analyses. Levels not reported.	No associations with average daily 1-h concentrations of ozone and end points examined (total, cardiopulmonary, and lung cancer deaths) in either of the 6-month periods (April-September and October-March).	Ozone data available for 117 of 151 metropolitan areas. Focus of the study was fine particles and sulfates. Analyses using peak ozone part of sensitivity analyses of PM effects.
Lipfert et al., 2000	National cohort of approximately 70,000 US veterans diagnosed with hypertension in the 1970s. About 21 years of follow-up.	Hybrid design in the sense defined above. Cox proportional hazards used for analyses. Peak ozone in four distinct exposure periods considered for analyses: pre-1974, 1975-1981, 1982-1988, 1989-1996.	The mean 95th percentiles for ozone in the four periods were as follows:1960-1974, 132 ppb;1975-1981, 140 ppb;1982-1988, 94 ppb;1989-1996, 85 ppb.	Among the pollutants NO_2 and peak ozone were associated with concurrent mortality risk, but only the former with delayed risk. The mortality excess relative risk associated with ozone was reported to be about 10% at an 'adjusted' mean. How this adjustment was made is not entirely clear. There was a suggestion of a threshold for ozone at about 140 ppb.	This study is noteworthy because the adjustment of selected ecological covariates was done at the zip code level. This procedure presumably leads to better adjustment than one done at the city level. Hypertensive veterans are almost certainly not representative of the general population. Hence the generalizability of results to other populations is questionable.
Lipfert et al., 2006a, 2006b	Update of the Lipfert et al., 2000 study above with follow-up through 2001.	Hybrid design. Cox proportional hazards model used for analyses. For measures of ozone, see above.	See above. For the period 1997-2001, the peak ozone concentratioo is reported to be 84 ppb.	Ozone is significantly associated with mortality in the period 1989-1996, but not in 1997-2001. The authors conclude that traffic ensity is a much better predictor of mortality than any component of the air pollution mix.	This study is noteworthy for using a precisely defined measure of traffic density rather than proximity to a major highway.
Jerrett et al., 2005	Extension of the ACS II study to Los Angeles. Twenty-three thousand subjects with about 5000 deaths over the period 1982-2000. Focus was on fine PM. Ozone exposures interpolated from 42 fixed-site monitors.	Hybrid design. Cox proportional hazards model used for analyses.	Not reported	No association of ozone with mortality with two measures of exposure, expected peak daily concentration and average of four highest 8-h maxima.	Ozone exposure interpolated from 42 fixed-site monitors to the zip code level.

*Since this Report was prepared, a paper by Jerrett et al. (2009) has been published that reports analyses indicating that long-term exposure to ozone may increase mortality from respiratory diseases.

Individual-level information on some covariates likely to confound the association between air pollution and mortality, such as cigarette smoking, is collected and used in the statistical analyses. However, information on exposure to air pollution is available only at the population level from central monitors in the cities from which the cohorts are drawn. Thus, inferences regarding the association between air pollution and mortality are based upon differences in the levels of air pollution in the different areas in which the study is conducted. Most of the long-term studies have focused on the association of fine PM and mortality. Some studies considered the gaseous pollutants, but only as possible confounders of the association of fine PM with mortality. Table 1 describes the main features of the major long-term studies that considered ozone.

Before discussing the studies that have examined the relationship between long-term exposure to ozone and mortality, it is appropriate to discuss briefly a recent paper by Janes et al. (2007) on the issue of unmeasured confounding in epidemiologic studies of fine PM and mortality. The paper raises serious questions regarding the validity of previously reported associations between fine PM and mortality and, in turn, has important implications for the association between ozone and mortality. Janes et al. (2007) use a new approach to investigating confounding in air pollution studies. There have been substantial decreases in air pollution in the United States, including fine PM pollution, in parallel with decreases in death rates. It is difficult, however, to attribute the decline in death rates to a decline in pollution because of the myriad other changes in demographics and lifestyle that have also occurred over the same period of time.

The authors note that the association between national trends in fine PM and mortality "is likely to be confounded by slowly time-varying factors, such as changes in industrial activities and the economy, improving health care, and large scale weather events." However, these associations at the local level are less subject to confounding and, therefore, a positive association detected at this level would be more likely to reflect a causal association between fine PM and mortality. Moreover, if fine PM pollution is causally associated with mortality, then areas of the country that have seen large declines in fine PM pollution should also see larger declines in mortality than areas of the country in which there have been more modest declines in fine PM pollution.

To test the hypothesis that declines in fine PM pollution are causally associated with declines in mortality, they use a statistical approach that decomposes the association between fine PM and mortality into a contribution at the national level and another at the local level. They analyze the association between fine PM and mortality in 113U.S. counties over the 3-year period 2000–2002, and report associations between fine PM and mortality at the national, but not the local, level, and conclude that "if the association at the national scale is set aside, there is little evidence of an association between 12-month exposure to $PM_{2.5}$ and mortality." This conclusion suggests that the reported associations between fine PM and mortality are not causal but can be explained by confounding. Strengths of the study include the number of counties included in the analyses, the robustness of results to sensitivity analyses, and the use of regression calibration methods to adjust for possible measurement error. In view of these results and given the strong associations of PM and mortality reported in other studies, one can only wonder what would happen if similar analyses were conducted with ozone.

The long-term studies of air pollution and mortality, which were central to the Agency's decision on the NAAQS for PM, play little or no role in the Agency position on ozone. The Staff Paper presents a brief discussion of long-term studies of air pollution and mortality. With the exception of the Veterans' study discussed below, these studies reported no evidence of an association between ozone concentrations and mortality. As Krewski et al. (2000) note in their reanalyses of the Harvard Six Cities Study, "The Six Cities Study, with its small number of cities and high degree of correlation among the air pollutants monitored, did not permit a clear distinction among the effects of gaseous and fine particle pollutants. Indeed, estimates of the relative risk of mortality from all causes were similar for exposure to fine particles, sulfate, sulfur dioxide, and nitrogen dioxide. Of the gaseous co-pollutants in the Six Cities Study, *only ozone did not display an association with mortality.*" Similarly, Krewski et al. (2000) found little evidence of association between ozone and mortality in their reanalyses of the ACS II study. In a study in Los Angeles based on the ACS is American Cancer Society cohort, Jerrett et al. (2005) found no evidence of an association between ozone and mortality.

The U.S. Veterans' Cohort Study (Lipfert et al, 2000) is the only long-term study of air pollution and mortality to report significant associations between ozone and mortality. The cohort consists of approximately 70,000U.S. veterans who were diagnosed with hypertension in the mid 1970s. The cohort had an average age of about 51 at recruitment, is all male, and is about 65% white and 35% non-white. In addition to air pollution variables based on county of residence, which were considered in some detail, information on individual level covariates, such as smoking, were included in the analyses. In contrast to the original Six Cities and ACS II studies, all measured criteria pollutants, with the exception of lead, were considered in the analyses. As in the Harvard Six Cities and the ACS II studies, the basic analytic tool was Cox proportional hazards regression. Four different exposure and three different mortality periods were considered, yielding a total of 12 distinct exposure and mortality period combinations for each pollutant. Among the pollutants, the strongest associations were seen with NO_2 and peak ozone. Of these two pollutants, the authors reported that ozone showed the stronger association with mortality, although there was an indication of a threshold at about 0.14 ppm for ozone effects. No significant PM association was seen with any of the various measures used (total suspended particulate [TSP], PM_{10}, sulfates, fine PM). The authors point out, however, "it must be recognized that all potentially harmful pollutant species are not measured routinely and thus cannot be included in epidemiology studies of this type. For this reason, those pollutants that are included should be considered as indices of the overall urban pollution mix. Further the nature of this mix has changed significantly during the period evaluated in this study."

Whereas the original Veterans' Cohort Study (Lipfert et al., 2000) was briefly discussed in the Staff Paper, a recent update was not (Lipfert et al., 2006a, 2006b). The updated study extends the mortality follow-up of the Veterans' Cohort through 2001 and considers data on county-level traffic density as a predictor in the regression analyses. The authors report that traffic density is a better predictor of mortality than any of the ambient air quality measures, including fine PM:

> *"Traffic density is seen to be a significant and robust predictor of survival in this cohort, more so than ambient air quality, with the possible exception of ozone. Stronger effects of traffic density are seen in the counties that have ambient air quality monitoring data, which also tend to*

have higher levels of traffic density. These proportional-hazard modeling results indicate only modest changes in traffic-related mortality risks over time, from 1976–2001, despite the decline in regulated tailpipe emissions per vehicle since the mid-1970s. This suggests that other environmental effects may be involved, such as particles from brake, tire, and road wear, traffic noise, psychological stress, and spatial gradients in socioeconomic status."

Lipfert et al. (2000, 2006a) reported associations between peak ozone, but not mean ozone, and mortality in the original and updated analyses. As noted above, the authors reported evidence of a threshold for peak ozone at about 0.14 ppm based on analyses of deaths during the period 1982–1988. The association appeared to be strongest for mortality in the period 1989–1996, but apparently the authors did not address the issue of a possible threshold. For the period 1997–2001, the association was not statistically significant.

The EPA Staff Paper (2007a) concluded that "consistent associations have not been reported between long-term ozone exposure and all-cause, cardiopulmonary or lung cancer mortality." The results of the long-term studies raise issues in the interpretation of time-series studies of ozone and mortality. Kunzli et al. (2001) distinguish four possibilities regarding the association of air pollution with mortality: "1) air pollution increases both the risk of underlying diseases leading to frailty and the short-term risk of death among the frail; 2) air pollution increases the risk of chronic diseases leading to frailty but is unrelated to timing of death; 3) air pollution is unrelated to risk of chronic diseases but short-term exposure increases mortality among persons who are frail; and 4) neither underlying chronic disease nor the event of death is related to air pollution exposure." They go on to argue that time-series studies capture deaths from categories 2 and 3, whereas long-term studies capture all the deaths associated with air pollution. They conclude that time-series studies underestimate the number of deaths attributable to air pollution and recommend that estimation of the impact of air pollution on mortality be based on long-term studies. In a later paper, Burnett et al. (2003) offer an alternative approach to understanding the relationship between time-series and cohort studies. They partition the hazard function into components related to long-term and short-term exposures to air pollution. This approach provides a framework for understanding the discrepant findings of the time-series and long-term studies of ozone and mortality. At the very least, the Agency should address the conundrum raised by the absence of an ozone effect in long-term studies. As one of the reviewers of this report suggested, perhaps the underlying mechanisms for producing effects are different.

Short-term morbidity and mortality (time-series) studies

In a time-series study, daily data are collected over a number of years, covering mortality or some other end point of public health interest (e.g., hospital admissions, asthma attacks in children). These responses are then included in a Poisson regression analysis where the explanatory variables include long-term trend and/or seasonality, meteorology, and air pollution. Long-term trend and seasonality are typically modeled as a smooth function of time, either through some expansion (e.g., splines) or through the generalized additive modeling (GAM) approach. Meteorology is modeled through a variety of different approaches, most often involving temperature and dew point. Finally, the air pollution variable of interest (in this discussion, ozone) can be modeled either linearly or nonlinearly, using a variety of lags, and either on its own or in conjunction with other pollutants (co-pollutants). In ozone studies, the most commonly used lag is 0 (in other words, current day's ozone is used as a predictor of current day's mortality), but it is also common to study ozone at a lag of 1 or 2 days, or some average over lags 0 and 1 or lags 1 and 2. An alternative model is the distributed lag model, in which ozone lags of up to 6 days are included in the model with separate regression coefficients for each lag. Day of week is also typically included as an explanatory variable, and some studies have been restricted to summer months because it was found that summer data produce the most significant association for ozone. All of this analysis is done initially one city at a time, but in recent years many studies have been multi-city. The inspiration for multi-city approaches was the NMMAPS study, which started as a study of particulate matter (PM) effects but in recent years has been extended to include ozone. NMMAPS stands for the National Morbidity, Mortality and Air Pollution Study, based at Johns Hopkins University.

Multiple city results

The main results of the NMMAPS study on ozone are summarized in the paper by Bell et al. (2004). This study used data from 95 U.S. cities covering the period 1987–2000. The authors used a distributed lag model with data on 24-h ozone averages for lags 0–6. Long-term trends were modeled through smoothing splines of between 7 and 21 degrees of freedom per year. Meteorology was modeled through temperature at lag 0, the average of temperature at lags 1–3, dew point at lag 0, and the average of dew point at lags 1–3, each modeled nonlinearly through smoothing splines. Interaction terms were included to separate mortality counts into three age groups (<65, 65–74, 75 and over) through a common regression function applied for all three groups. The analyses covered year-round data though many cities were implicitly restricted to summer months because only summer ozone data were available. After calculating a single regression coefficient, with corresponding standard error, to represent the overall change in ozone associated with a 10-ppb rise in 24-h average ozone in each city, the results were combined across cities using a Bayesian hierarchical analysis. Although one set of results was expressed at the level of individual cities, most of them were summarized as an overall national average relative risk.

The result of this analysis was that a 10-ppb rise in 24-h average ozone was associated with a 0.52% rise on total mortality (excluding accidental deaths), with a 95% Bayesian credible interval (equivalent for all practical purposes to a

95% confidence interval) of 0.27%–0.77%. This is for a distributed lag model: the corresponding result for lag 0 alone was 0.25%, credible interval 0.12%–0.39%. If deaths were restricted to cardiovascular and respiratory causes, the corresponding relative risk estimate based on a distributed lag model was 0.64%, credible interval 0.31%–0.98%. Using the same model to analyze the three age groups separately resulted in slightly different estimates, e.g., the 65–74 age group has an estimated relative risk of 0.70% (credible interval, 0.28%–1.12%), with results for the other two age groups almost identical to those from the combined age group model. If results were restricted to summer days (April to October) the estimated relative risk actually went down, from 0.52% to 0.39% (credible interval, 0.13%– 0.65%).

The question of a co-pollutant effect due to PM is complicated by the fact that most cities do not have daily records of either PM_{10} or $PM_{2.5}$. Therefore, comparisons are only possible using single-day lags. The paper included single-city comparisons of the estimates computed both with and without a PM_{10} adjustment, though no overall national estimate was quoted for the relative risk estimate with PM_{10} adjustment. Nevertheless it was claimed that the overall results were robust to the inclusion of either PM_{10} or $PM_{2.5}$. This result has been challenged by Smith et al. (2009) who showed that when PM_{10} is included as a co-pollutant, the estimated ozone effect typically goes down by about 25%, which they view as being a significant effect.

Another recent paper on PM confounding for ozone is Bell et al. (2007). This paper extended the results of Bell et al. (2007) by including numerous other analyses along similar lines to the earlier paper. The overall conclusion that the authors reached was still that confounding by particulate matter is not an issue in ozone studies. However, Table 2 of that paper does show about a 25% reduction in the point estimate of the ozone effect, when PM_{10} is included as a confounder. Thus, there still seem to be differences of interpretation of these analyses.

Other multi-city studies were also covered in the EPA Staff Paper (2007a). In another paper from the NMMAPS group, Huang et al. (2005) analyzed data for cardiovascular and respiratory mortality for 19 cities from 1987 to 1994 (compared with 95 cities, 1987–2000 for the full NMMAPS study). The data were restricted to summer months (June through September). The analytical method was essentially the same as in Bell et al. (2004) though is different in some details, e.g., the age group effect was modeled only as a single indicator variable for each age group rather than smooth curves as in Bell et al. (2004). For the possible confounding effect of PM_{10}, only single-lag models were appropriate for the reason discussed earlier: for both ozone and PM_{10} at lag 2 (the lag where the discrepancy between the with-PM_{10} and without-PM_{10} results was largest) the estimated ozone effect was 0.64% (credible interval, 0.17–1.07%) when PM_{10} was not included in the model, and 0.46% (−0.32%–1.17%) when PM_{10} was included. This is consistent with several other results reported later, that suggest the ozone effect is generally attenuated when PM_{10} is also included in the model. In this case, some confounding was also noted with either NO_2 or SO_2 included (singly) as co-pollutants.

Schwartz (2005) also performed a multi-city study, using 14 U.S. cities, but using the "case-crossover" design instead of a time-series analysis. In this design, the date on which an individual died is matched against an alternative date on which the individual did not die, and the ozone readings for the 2 days compared. To minimize the effect due to seasonality or long-term trend, the matching date is held close to the death date. Schwartz (2005) also matched for temperature. He found that a 10-ppb rise in ozone was associated with a 0.57% (95% credible interval, 0.02%–1.1%) increase in deaths, for the full-year analysis. It should be noted that Schwartz (2005) actually used daily 1-h maximum ozone, not 24-h average as in the NMMAPS papers, but for the results reported here, in order to make comparisons with results from other papers, we have converted to 24-h average ozone using the conversion factor that a 1-ppb rise in 24-h ozone corresponds to a 2.5-ppb rise in 1-h daily maximum ozone (Thurston and Ito, 2001). Later in this report we will discuss the issue of using conversion factors for converting concentration-response coefficients from one ozone metric such as 1-h maximum concentration to a second metric such as 24-h concentration. With that conversion, the main result is very similar to the main result of Bell et al. (2004) (the credible interval is wider, but that is most likely a consequence of the smaller number of cities used in the analysis, not to mention an alternative study design). Schwartz (2005) also reported, however, that when restricted to winter months, no association was found (point estimate −0.32%, credible interval −1.32%–0.7%) but when restricted to summer months, an increased relative risk was estimated (0.92%, credible interval 0.27%–1.55%). In a slightly different analysis in which temperature was accounted for through regression rather than by matching, Schwartz (2005) found that including PM_{10} as a co-pollutant made no difference at all to the point estimate (0.47% in each case).

As part of a meta-analysis to be discussed in more detail later, Ito et al. (2005) carried out a time-series analysis on seven U.S. cities in order to look at model sensitivity issues. They analyzed the data by methods similar to Bell et al. (2004, 2005) but using four different meteorological models, from a "quintiles indicator variables" approach that they attribute to Moolgavkar et al. (1995), to a "4 smoother" model that is effectively equivalent to the meteorological adjustment approach of Bell et al. (2004, 2005). Relative risk estimates were computed separately for winter and summer data though the winter estimates were generally not statistically significant. Comparisons were also made for ozone relative risk estimates with and without either PM_{10} or $PM_{2.5}$ as a co-pollutant. The results were combined across six of the cities (the seventh city, New York, was not included because no PM data were available). The biggest difference among the results was associated with the different weather adjustment models. For example, for all-year data without PM the combined estimate was a rise of 1.0% (0.55%–1.45%) associated with a 10-ppb rise in ozone based on the quintiles approach to meteorology, versus 0.5% (0%–1.0%) using the 4 smoother approach. For summer results including a PM adjustment, the corresponding results were 1.0% (0.3%–1.7%) using the quintiles approach and 0.55% (−0.05%–1.1%) using the 4 smoother approach.

The final multi-city analysis we discuss here is Gryparis et al. (2004) based on 23 European cities in the APHEA project (Air Pollution and Health: A European Approach). We note in passing that although this is not a U.S. study, it was cited in the EPA Criteria Document (2006) and some of the meta-analyses that are reported later also combined results from U.S. and non-U.S. cities. For these reasons, we believe it is important to note when results from U.S. and non-U.S. cities produce substantially different estimates. Gryparis et al. (2004) used a very similar approach to Bell et al. (2004), though they did not describe the long-term trend and meteorology corrections in enough detail to make a precise comparison. In their study, ozone is measured in $\mu g/m^3$, which we convert to ppb at the rate of 1.96 $\mu g/ m^3$ equals 1 ppb (Bell et al., 2005). They also used 1-h daily maximum ozone, which we convert to 24-h average ozone using the same 2.5 conversion factor noted previously. With these changes, their main result is that a 10-ppb rise in 24-h ozone is associated with a 1.62% rise in total mortality, with a 95% credible interval of 0.83%–2.55%.

Possible explanations for the different estimates include different exposure patterns in European cities (due, e.g., to greater use of public transport), different placement of monitors in European cities, and differences in the statistical modeling strategy. It is also possible that ozone is serving as a proxy variable in both the United States and European studies for some missing causative factor and that the ratio between levels of ozone and the causal variable might be different for the two continents as well as within each continent.

The published multi-city studies put a huge emphasis on the overall nationally averaged effect, but this ignores the very real differences that are evident among different cities. For example, in the NMMAPS analysis, our Figure 2 essentially reproduces Figure 2 from Bell et al. (2004), showing the posterior estimates (calculated by the Bayesian hierarchical approach) of ozone-mortality coefficients in each of the 98 cities in the study. Figure 2 in this report extends the Bell et al. (2004) figure, independently recalculated by Smith et al. (2009). In addition to reproducing the posterior estimates of Bell et al. (2004), this figure also shows the raw estimates and posterior estimates under an alternative "regional prior." The substantial variability among the raw estimates for the 98 cities is very evident. The posterior estimates under the regional prior also differ from those under the national prior. The analyses by both Bell et al. (2004) and Smith et al. (2009) yielded statistically significant coefficients for only a few cities (New York, Newark, Philadelphia, Dallas-Fort Worth, Chicago, and Houston), with the vast majority of the cities not having statistically significant coefficients. Moreover, the raw estimates shown in Figure 2 (before the Bayesian part of the calculation) show a far greater variability among the cities, with about a third of the coefficients negative. In our view, it is very important to take into account the variability of the ozone-mortality coefficients in the individual cities, especially when the coefficients are applied to risk analyses, but this does not appear to have been done in current EPA analyses.

In Figure 3, taken from Smith et al. (2009), regional weighted averages of the posterior mean prior estimates are shown. It is apparent that statistically significant positive coefficients were obtained only for the Northeast, Industrial Midwest and Southeast. In other areas of the country, there is no apparent effect of ozone on mortality.

A national coefficient is shown in Figure 2 following the example of Bell et al. (2004). A national coefficient is also shown in Figure 3. In our view, the national coefficients are of limited value in view of the substantial variability that is evident on a city-to-city basis and from one part of the country to another.

Another issue raised by the NMMAPS papers is that with one exception, they calculated all their ozone-mortality coefficients based on 24-h ozone. In our view, they should have used the maximum 8-h ozone in any day, because the EPA standard is based on this variable. As an example, Figure 4 shows estimated coefficients for individual cities and Figure 5 shows the corresponding regional values based on the maximum 8-h ozone metric. Once again we note that only a handful of the cities have statistically significant ozone-mortality coefficients, whether these are assessed by the raw or posterior estimates. The one exception to citation of an 8-h ozone metric is that Bell et al. (2004) did calculate a national average effect for the 8-h average. The value obtained is consistent with the national effect coefficient shown in Figures 4 and 5.

As noted earlier, a number of investigators have converted ozone concentration–health effects coefficients obtained with one metric, such as the 1-h maximum concentration, to a second metric, such as the 24-h average concentration. The validity of this approach is open to question, as demonstrated by Smith et al. (2009) who calculated concentration-mortality coefficients for each of the 98 cities using all three time metrics. Even for a single city, it is not well established that the concentration-mortality coefficient for the three metrics (1-h maximum, 8-h maximum, and 24-h average) have a consistent relationship. It is quite possible that one of the three metrics may be more strongly associated with a particular health outcome, such as excess mortality, than the other metrics. The relationship between the three metrics varies over time for any given city and is certainly variable among cities. The association between concentration and excess mortality across the cities in the NMMAPS data set for all three metrics is quite variable, as demonstrated by Smith et al. (2009). Scatter plots of the relationship between the 24-h and 8-h posterior estimates and between the 1-h and 8-h posterior estimates are shown in Figure 6. It is readily apparent that the relationship of the coefficients for the different metrics for individual cities is so variable that use of a single "national" conversion coefficient for multiple cities

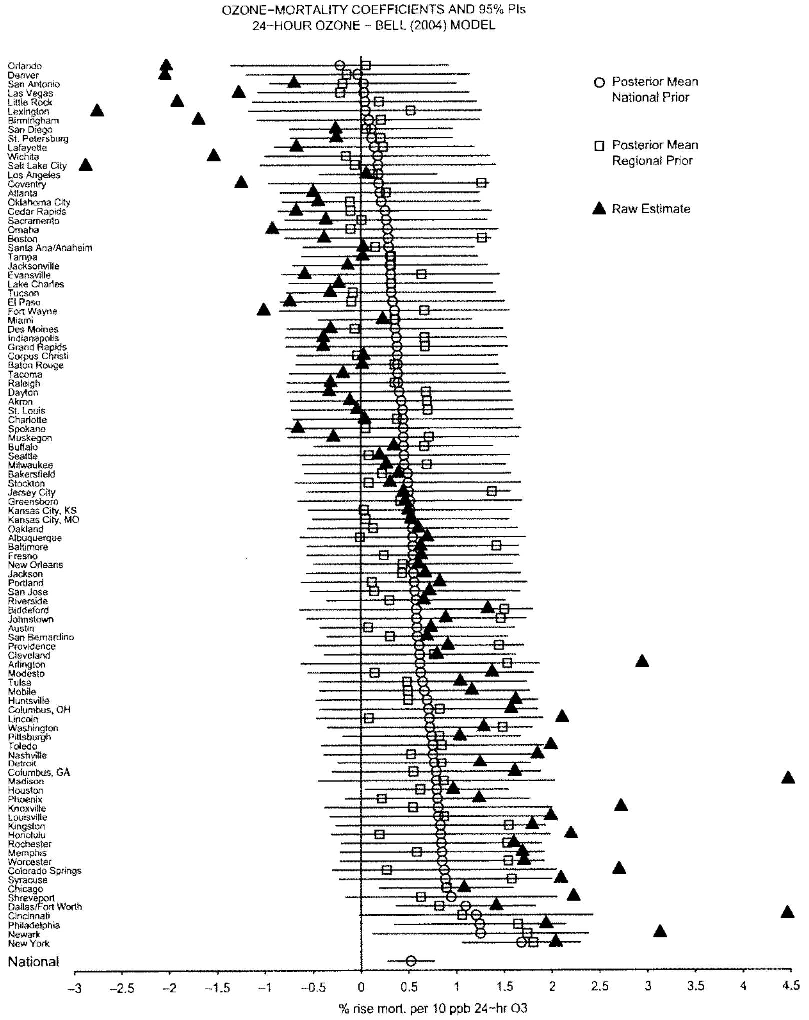

Figure 2. Ninety-five percent posterior intervals for the ozone-mortality coefficients, all-year data, by the hierarchical Bayesian method as in Figure 2 of Bell et al. (2004). The Bayesian posterior estimates under the "national prior" (circles) are shown alongside those for the "regional prior" (squares) and the raw maximum likelihood estimates (triangles) (Figure 1 of Smith et al., 2009).

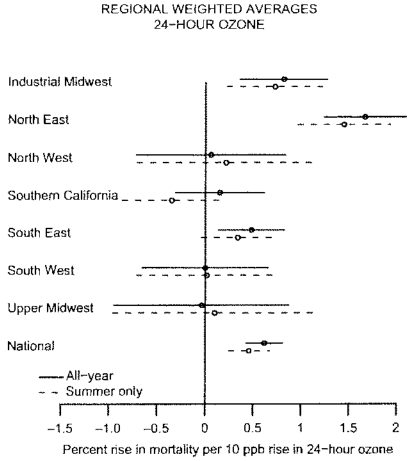

Figure 3. Regional estimates of population-weighted average regression coefficients based on 24-h ozone, with 95% PIs (based on data in Table 3 of Smith et al., 2009).

in a meta-analysis would lead to erroneous estimates of the converted coefficient for many cities.

Meta-analyses and evidence on publication and model selection biases

Meta-analyses are different from multi-city time-series studies in that they rely on previously published studies; there is therefore the possibility of *publication bias* owing to the tendency that statistically insignificant results may not get published at all. A second distinction between multi-city analyses and meta-analyses is that in the former, it is possible to ensure that exactly the same regression model is fitted in each city, whereas in meta-analyses this is hard to control, raising the possibility of *model-selection bias*, i.e., the bias that results when many models are compared but only the largest or the most statistically significant association is reported. A recent collection of papers in the journal *Epidemiology* provides evidence of both kinds of bias.

Bell et al. (2005) analyzed data from both U.S. and non-U.S. cities. The studies used different lags from 0 to 2, but Bell et al. (2005) used results from lag 0 where possible to maintain the greatest comparability among studies (they also showed that the lag 0 studies led to the largest estimates overall). None of the studies in the meta-analysis used distributed lag models. Data were combined across different studies using Bayesian hierarchical models, similar to their multicities study (Bell et al., 2004). This method is theoretically superior to the non-Bayesian techniques used in other meta-analyses because it takes into account the uncertainty in estimating the intercity variance, and thereby leads to slightly wider credible intervals, though for most practical comparisons the Bayesian and non-Bayesian meta-analysis methods should lead to similar results. Where different types of mortality were concerned, the estimates for cardiovascular mortality were higher than those for total mortality, but those for respiratory mortality were lower. They looked at whether estimates were changed by including a PM adjustment, concluding that they were not. Table 3 of their paper showed much wider credible intervals in the case of PM-adjusted estimates, but this may be because only a subset of the studies used a PM adjustment. In comparisons between year-round and summer-only estimates, they found that summer-only studies produced almost twice the estimated relative risk (1.50% with a credible interval from 0.72% to 2.29%) for total mortality based on combined U.S. and non-U.S. data. The relative risk estimated for all-season total mortality was 0.87% (credible interval, 0.55%–1.18%).

The meta-analyses reported by Bell et al. (2005) were kept separate from the NMMAPS results of Bell et al. (2005). However, eight of the meta-analysis cities were also NMMAPS cities. For lag 0 ozone, all-year total mortality, the estimate of Bell et al. (2004) was 0.25% (credible interval 0.12%–0.39%) for 95 cities in NMMAPS. This is to be compared with the just-quoted meta-analysis result of 0.87%, which seems clear evidence of a publication bias in the use of previously published results. However for the eight cities that are common to both studies, Figure 2 in the paper by Bell et al. (2005) also shows the individual-city estimates and confidence intervals. Strikingly, in every case the estimate included in the meta-analysis is larger than the NMMAPS estimate for that city. Bell et al. (2005) attribute this result to publication bias but it seems unlikely that a discrepancy could arise for this reason alone (e.g., even if these eight cities had been selected from a larger set of cities as the ones with the largest ozone effects, that is not sufficient reason why the estimates should be different when reanalyzed by NMMAPS). At least part of the reason must be the difference in modeling approaches—the fact that NMMAPS was careful to use the same model in all cities, whereas the other published papers, by different authors using different modeling strategies, were more likely to have selected the model to maximize the relative risk estimate. In other words, these comparisons show evidence of model selection bias as well as publication bias.

Ito et al. (2005) used results from 11 U.S. and 25 non-U.S. cities, with a "selected" lag of up to 3 days in each city (they did not say how they made the selection). They looked at mortality effects by season and confounding by PM. Results from different cities were combined by a non-Bayesian meta-analysis procedure (DerSimonian-Laird). Overall they found a risk increase of 0.8% (95% confidence interval, 0.55%–1.0%) associated with a 10-ppb rise in 24-h ozone. However, among studies reporting a seasonal breakdown, the results were 1.1% (0.4%–1.8%) for the all-year relative risk and 1.75% (1.05%–2.45%) for summer, again showing clearly that relative risk estimates are higher during the summer. The results showed little effect due to confounding by

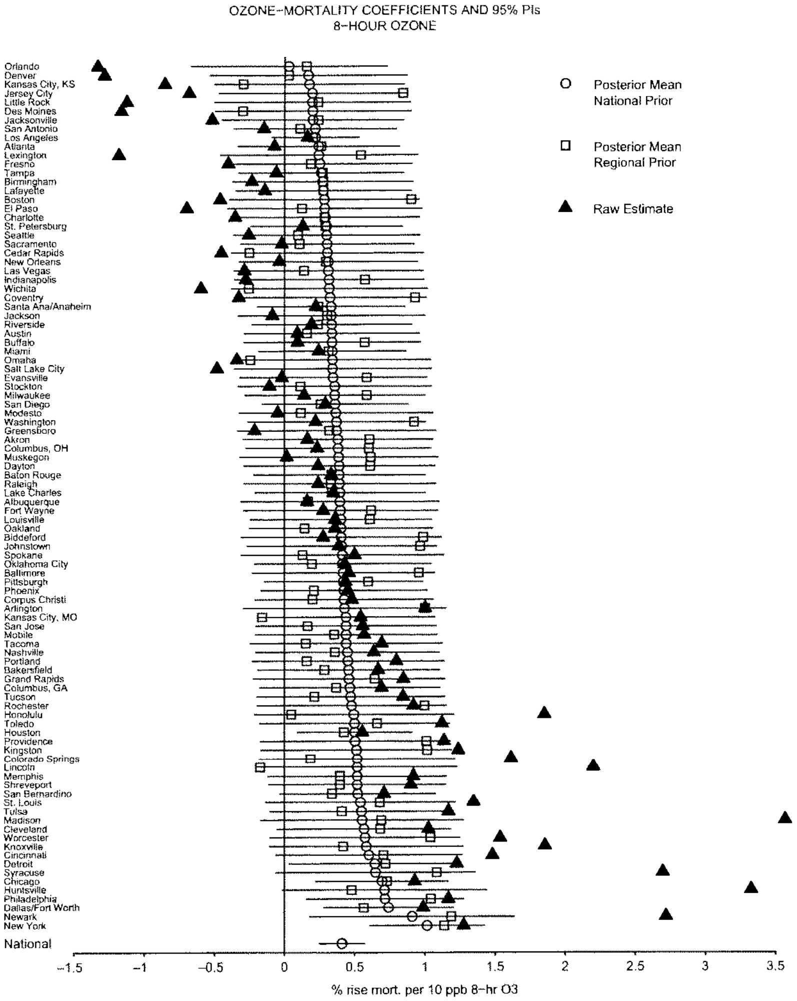

Figure 4. Ninety-five percent posterior intervals for the ozone-mortality coefficients, based on 8-hour ozone, all-year data. The Bayesian posterior estimates under the "national prior" (circles) are shown alongside those for the "regional prior" (squares) and the raw maximum likelihood estimates (triangles) (Figure 4 of Smith et al., 2009).

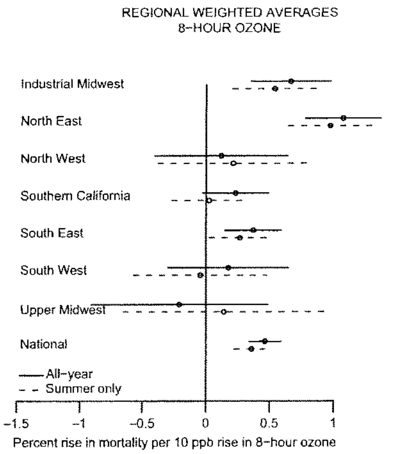

Figure 5. Regional estimates of population-weighted average regression coeficients based on 8-h ozone with 95% PIs (based on data in Table 3 of Smith et al., 2009).

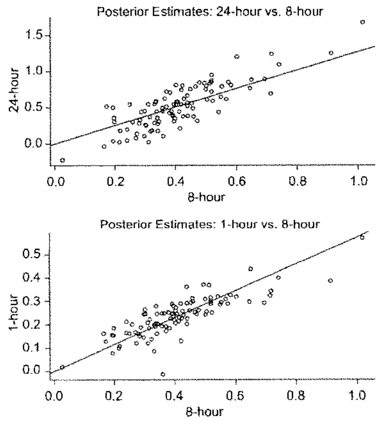

Figure 6. Scatter plots of posterior estimates corresponding to 24-, 8-, 1-h ozone (Figure 3 of Smith et al., 2009).

PM, though in cases where both sets of relative risks were computed (with and without PM), the estimates with PM were lower. There was some evidence of publication bias as determined through an asymmetry test. In some cases, different studies using the same city's data showed marked contrast in the results, which is further evidence of a model selection bias. As noted already, in the same study, Ito et al. (2005) also did a multi-city analysis with seven U.S. cities, which amplified the issue of model-selection bias.

The third meta-analysis, by Levy et al. (2005), found a combined risk increase of 0.21% (confidence interval, 0.16%–0.26%) associated with a 10 ppb increase in 1-h daily maximum ozone. Using the same conversion factors defined earlier, this translates to an estimated relative risk of 1.03% (0.78%–1.27%) associated with a 10-ppb rise in 24-h average ozone. Thus the magnitude of the association was quite similar to those of the other two meta-analyses (but still substantially higher than NMMAPS). An original feature of their analysis was that it accounted for air-conditioning use (using publicly available Census data), showing that the ozone-mortality association is higher where there is lower use of central air conditioning. Some subsequent papers such as Bell and Dominici (2008) and Smith et al. (2009) have shown similar effects in the NMMAPS data. The implication of these analyses is that people who have central air conditioning in their homes are exposed to much lower ozone when indoors in summer.

Taken together, the meta-analyses provide evidence of publication bias and model selection bias. Particularly striking are the contrasts between the three fairly similar relative risk estimates from the meta-analyses, and the much lower estimate in NMMAPS. These analyses also provide evidence that model-selection bias may alter the magnitude of the estimated association by a factor of 2, or even 4, if the distinction between the NMMAPS and AHPEA results cannot be attributed to other differences in both air pollution and mortality patterns between United States and European cities.

Nonlinear exposure-response relationships

All the studies reported so far have used essentially a linear ambient concentration-response curve (on a log scale, i.e., the logarithm of expected deaths is linear in ozone). Bell et al. (2006) looked in the NMMAPS data for evidence both of a threshold (no change in mortality associated with ozone below a certain threshold) and for a nonlinear ambient concentration-response curve (in which the entire curve of expected deaths versus ozone is constructed as smoothly nonlinear). The evidence for a threshold, if there were one, would be of obvious relevance to the determination of a standard, but even in the absence of a threshold, the use of a nonlinear ambient concentration-response curve, if it could be reliably estimated, could potentially be of great value is risk assessment.

For this analysis, Bell et al. (2006) did not attempt a distributed lag model (which would involve even more technical complications), but confined themselves to the average 24-h ozone at lag 0 and lag 1 as the main ozone-related predictor of mortality. When the earlier linear concentration-response analysis was repeated with this measure of ozone, the estimated rise in mortality per 10 ppb increase in ozone was 0.32%, with a 95% credible interval from 0.17% to 0.46%.

This is compatible with the results of Bell et al. (2004), who showed a lower relative risk when confined to any single lag, but a higher relative risk using a distributed lag model. However, Bell et al. (2006) repeated the analysis on subsets of days defined by various thresholds—in one analysis, they fitted the same model but restricted to days on which the lag 0 and lag 1 average of 24-h ozone was less than *s*, where the values of *s* ranged from 60 ppb down to 5 ppb. For values of *s* down to 30 ppb, there was very little change in the estimated relative risk, which remained clearly statistically significant according to the authors' own Figure 2. Their own interpretation of this result was that it proved ozone still had deleterious health consequences at levels much lower than the current ozone standard.

We have several comments about this analysis. The first is that the conclusions in their paper are not entirely supported by the evidence presented—for example, they say "Daily changes in ambient O_3 were significantly associated with daily changes in the number of deaths...even when we used data that included only days with lag 01 average O_3 levels < 15 ppb." However, the result they present for 15 ppb is clearly not statistically significant.

A second comment is that there seems something odd about the claim for significant effects at very low levels of ozone—not only well below the current ozone standard but even the vast majority of the data. Observing the same effect in a more restricted study (for the city of Vancouver), Vedal et al. (2003) questioned whether such results could truly be indicative of a causal ozone effect, suggesting that the unmeasured effect of other air pollution or uncontrolled features of meteorology may be responsible.

However, another issue here concerns the relevance of concentrating on low ozone values anyway, given that the ozone levels of most relevance as far as the standard is concerned are between 60 and 80 ppb of 8-h ozone. Smith et al. (2009) estimated a piecewise-linear ozone-mortality association based on separate linear relationships for the ranges 0–40, 40–60, and 60–80 ppb (8-h ozone). They found, consistent with Bell et al. (2006), that the association on 0–40 ppb is statistically significant, as is that on 40–60 ppb, but they did not find a statistically significant association between 60–80 ppb except in the Industrial Midwest region. Only by combining data across the three ranges (in effect, assuming a linear ozone-mortality relationship across 0–80 ppb of 8-h ozone) were they able to establish a statistically significant association, but this raises the question of why do a nonlinear analysis at all. In summary, it looks as though Bell et al. (2006) looked at the wrong range by focusing on very low ozone exposures rather than concentrating their analysis on the range of interest for determining the standard.

The second part of the analysis by Bell et al. (2006) was aimed at estimating a nonlinear dose-response curve. The stated method of doing this was via a spline approach with knots at 0, 20, 40, and 80 ppb (but not 60 ppb). The result shown in Figure 3 of Bell et al. (2006) showed a steadily increasing ozone association above about 15 ppb, and confidence bands that indicate a statistically significant association above about 40 ppb. In our own analyses, we have not succeeded in reproducing this exact result, though we have shown similar results using a piecewise linear approach (Smith et al., 2009). Given these and other concerns, we believe the whole question of nonlinear dose-response curves is still very much undecided at the present time. Nevertheless, we recognize it as a very important topic of future research.

Exposure error

A number of studies have examined correlations between personal and ambient exposure for both gaseous pollution and PM. In general, they have found that correlations are higher for either $PM_{2.5}$ or particulate sulfate (SO_4^{2-}) than for ozone. For example, in a study using personal monitors for three groups of sensitive subpopulations in Baltimore and Boston, Koutrakis et al. (2005) noted that "ambient concentration of gaseous pollutants serve as a better surrogate for personal exposure to $PM_{2.5}$ than for personal exposure to gaseous pollutants," though with the qualification that the ozone results were hard to determine because many were below the detection thresholds. Sarnat et al. (2006) reached a similar conclusion in a study conducted in Steubenville, Ohio, which showed "strong associations between ambient particle concentrations and corresponding personal exposure," but "most associations between ambient gases and their corresponding exposures had low slopes and R^2 values" (though the associations were still statistically significant). The EPA's Staff Paper (2007a) (section 3.4.2.1, pages 3-39 through 3-42) noted that Sarnat et al. (2005) found a statistically significant positive correlation between personal and ambient exposures to ozone, but failed to cite Koutrakis et al. (2005) at all, or to note the implication that ambient ozone may in fact be acting as a proxy for PM in epidemiological studies.

The direct effects of measurement error on regression estimates from time-series mortality studies have been investigated for particulate matter but not for ozone. For example, Dominici et al. (2000) presented a Bayesian statistical analysis, though based on rather limited information, about differences between personal and ambient exposure to PM. Brauer et al. (2002) showed by simulation that exposure error could well result in failing to detect a health effects threshold in the case of $PM_{2.5}$, though not for SO_4^{2-} where the personal-ambient correlation is much higher. They did not do a corresponding simulation for ozone, but because the other studies just cited have shown that the personal to ambient correlation is even less for ozone than for $PM_{2.5}$, a similar simulation for ozone would most likely reach the same conclusion.

Conclusions for time-series mortality studies of ozone

Single-city studies of the association between ambient ozone and mortality show a very wide range of results, with both positive and negative regression coefficients that are generally not statistically significant, even when the analyses are for large cities and long time periods (e.g., 14 years in the case of the NMMAPS study). However, a number of studies in recent years have shown a significant positive association in either multi-city studies (when time series from several cities are analyzed using the same statistical methodology and the results then combined) or in meta-analyses (in which previously published results are combined into a single overall estimate and confidence limit). Associations are strongest when confined to summer ozone; no study has found a significant association for winter data alone, though several (including the leading NMMAPS papers) have used all-year data without regard to season. All the studies employ corrections for long-term trend and seasonality, and include meteorological variables to avoid possible confounding. The ozone lags that are used vary considerably from one analysis to another, the most popular lags being days 0 (i.e., present-day ozone used as predictor of present-day mortality), 1, and 2. However, studies that have used a distributed lag model, in which the predictor of mortality is a weighted average over the past week, estimate the largest overall ozone relative risk.

Despite the impression given in EPA's criteria document and staff paper that these results are very consistent across different studies, closer scrutiny shows this not to be the case, even when the results are standardized with respect to ozone metric used (the results quoted here are for a 10-ppb rise in 24-h average ozone, to the extent we can make an exact conversion). The results in the three meta-analyses collected in Levy et al. (2005) all find ambient ozone-mortality coefficients more than three times larger than the corresponding NMMAPS estimates, which seems indicative both of publication bias (only the larger or more significant results being published) and of model selection bias (reporting only results that give the largest or most statistically significant regression coefficient). Although the NMMAPS authors (Bell et al., 2004, 2006) have taken the greatest care in both compiling a large dataset and trying to control for other effects, including weather, there remain doubts about whether all possible confounders have been correctly allowed for. Moreover, by quoting most of their results in terms of an overall national average, they have ignored the very real differences among cities that are apparent in close scrutiny of their own analyses. For example, there are strong ozone-mortality associations in Chicago, New York City, and a few other northeastern cities, and also Houston and Dallas, but other large cities have very slight or negligible associations, e.g., Los Angeles, Atlanta, and Miami. There are a number of western cities, such as Denver, Salt Lake City, and Albuquerque, that were in compliance with the 0.084 ozone standard set in 1997, but are likely to be nonattainment with the new ozone standard set at 0.075 ppm. There is no evidence in any of the analyses of a significant ozone-mortality association for these cities.

None of the recent studies on ozone-mortality associations have looked explicitly at measurement error. However this is clearly a concern, because personal-ambient exposure correlations are lower for ozone than for particulate matter, and one recent study concluded that ambient ozone may be a better predictor of personal exposure to $PM_{2.5}$ than of personal exposure to ozone. This raises the possibility that observed associations between ozone and mortality may in fact be acting as a proxy for a PM-mortality relationship. Another study showed by simulation that for $PM_{2.5}$, measurement error may be responsible for failure to detect a threshold. Although a corresponding study has not been conducted for ozone, given the even weaker associations between ambient and personal exposures of ozone than exist for $PM_{2.5}$, it seems very likely that the same result would be true for ozone.

The question of confounding by PM may also be looked at by including PM_{10} or $PM_{2.5}$ directly in the analysis as a co-pollutant along with ozone. Where this has been done, the results have generally indicated a slightly weaker though still significant association with ozone. However, data availability issues complicate the comparison. In particular, in the United States most cities have collected PM_{10} data only once every 6 days, so in NMMAPS, it was not possible to conduct an ozone + PM_{10} analysis that would be directly comparable with the results for ozone alone. Even less data are available for ambient $PM_{2.5}$. Moreover differences in the degree to which exposures to each pollutant are correlated with actual individual exposures could allow ozone to serve as a proxy for one of the other pollutants, even if the other pollutant were to be included in the regression model.

Questions related to thresholds and nonlinear ambient ozone-mortality relationships remain open at the present time. The recent study by Bell et al. (2006) reported a significant ozone-mortality association even when the analysis was confined to days with an ozone level below 15 ppb, though graphs in the same paper do not entirely support this conclusion. Whether an association found at such low ozone concentrations indicates a causal effect is questionable. The same paper also constructed a nonlinear dose-response curve showing an increasing ozone-mortality association above 15 ppb and a statistically significant association above 40 ppb (of 24-h average ozone). However, we have doubts about the methodology and feel that judgment should be reserved on this conclusion at the present time.

Time-series studies of ozone and hospital admissions

Parallel to the above studies about time-series analysis and mortality, there have been corresponding studies related to morbidity, by various measures such as hospital admissions for respiratory or cardiovascular diseases. Many of these studies were available at the time of the 1996 ozone review and there have been only a handful of more recent studies.

As an indication of some of the studies used in the 2006 risk assessment, Thurston et al. (1992) found significant associations between ozone and respiratory hospital admissions in three metropolitan areas (New York City, Albany, New York, and Buffalo, New York), for three summers (June–August, 1988–1990). This time period included the summer of 1988, which had extreme pollution levels. Schwartz et al. (1996) reviewed the methodology used in assessing pollution-morbidity relationships in time-series analysis (which raises more or less the same issues as do time-series mortality studies) and analyzed an illustrative dataset for Cleveland, Ohio, finding a significant association that, translated to a 10-ppb rise in 24-h ozone, would indicate a relative risk of 1.04, with a 95% confidence interval from 1.01 to 1.08 (in other words, the result was marginally significant). Linn et al. (2000) studied the effect of ozone, CO, NO_2, and PM_{10} with cardiopulmonary hospital admissions in Los Angeles from 1992 to 1995, finding the strongest association due to CO, and ozone relative risk coefficients that were either negative or not statistically significant. Likewise, Ito (2003) reanalyzed a dataset of Lippmann et al. (2000) that studied the association of several pollutants with hospital admissions in Detroit. The original study of Lippmann et al. (2000) had been affected by the "GAM bug" (Dominici et al., 2002)—this was a problem with some of the statistical analyses due to the use of inappropriate default convergence criteria in the statistical package SPlus, but the error was detected and corrected in all studies published in or after 2003. The results displayed by Ito (2003) focus almost entirely on particulate matter, but the original results of Lippmann et al. (2000) show in almost all cases no statistically significant association with ozone; the one exception (among many endpoints studied) was for hospital admissions due to heart failure, where they did find a small just-statistically significant association.

The hospital admissions literature differs from the mortality literature in that most of the papers consider data only for a single city or a very small group of cities (e.g., three in Thurston et al., 2000). The one moderately larger study hy Burnett et al. (1997) did find significant ozone associations with hospitalization for respiratory causes in 16 Canadian cities, although their methodology was much weaker than that used in recent multi-city mortality studies. For example, they did not include a detailed meteorology model.

The EPA's staff paper (2007a) compiled these and a number of other results into a diagram showing the associations of ozone with different health outcomes (Figures 3-4, pages 3-56). However, it is clear from this figure that most of the individual results are not statistically significant, even though positive coefficients outnumber negative ones.

In conclusion, the relationship between ozone and hospital admissions has been much less intensively studied than the corresponding relationship with mortality, with only one (comparatively small) multi-city study and no meta-analyses. Few new studies have been published since the 1996 EPA review (1996a), and the two post-2000 studies they cite do not support the conclusion of a statistically significant ozone association. All of these studies, however, are subject to the same limitations and uncertainties described for the time-series mortality studies because they use the same types of data for estimating exposures to pollution, and use the same statistical estimation methods.

Challenges of identifying effects of correlated pollutants

The best approach to analyzing epidemiological data, when multiple correlated pollutants might impact human health, has been under considerable debate in the scientific community. The traditional statistical approach for multipollutant analyses has been criticized on the grounds that introducing a correlated pollutant might attenuate the estimate of the 'true' relative risk of the pollutant under study. However, not including confounders such as co-pollutants can overestimate the relative risk of the pollutant under study. As a result, the same events are counted more than once when the population impacts of multiple single pollutant analyses are estimated. Thus, for example, the sum total of the estimated deaths due to pollutant A and the estimated deaths due to pollutant B, both derived from single pollutant models, can overstate the impact of the two pollutants in tbe real-world situation in which both pollutants coexist.

Panel studies

Panel studies generally involve a large uumber of repeated measurements of various indicators of effect in a relatively small group of well-defined subjects. As discussed previously (see "Exposure Assessment"), panel studies are one of the few designs in which individual-level exposure assessment (e.g., from personal monitoring) is feasible. With this design, even without personal monitoring, it is possible to characterize exposures with a high degree of accuracy and precision by limiting the study area and using study specific monitoring data. For example, studies of Korrick et al. (1998), Brauer et al. (1996), Kinney et al. (1996), and Delfino et al. (1996) are similar to earlier studies of children attending summer camps. Further, the design has the potential to focus on subjects with specified time-activity patterns. Generally, the weaknesses of panel study designs are their ability to be generalized to a larger population and the use of intermediate endpoints, often including measures of effect that may have undetermined clinical relevance, for example those in the study of Kinney et al. (1996).

New panel studies are listed in Table 8A-2 of the 2006 Criteria Document. In general, there are two types of panel studies that have been considered. Several studies (Brauer et al., 1996; Korrick et al., 1998) involved well-defined exposures to ozone in exercising individuals and were conducted in settings where impacts of co-pollutants were minimized. For example, Brauer et al. (1996) measured the association between ozone and morning and evening lung function in a group of outdoor berry pickers. Subjects were outdoors during the entire daytime period. Ambient monitors were at or very near the study locations aud personal monitoring assessed and evaluated exposure in a subset of the study subjects (mean difference = 2.5 ppb, $r = 0.64$). Korrick et al. (1998) measured lung function of hikers on Mount Washington and assessed their association with measurements of ozone at the mountain summit and base. Both studies measured particle mass and acidity although only Korrick et al. (1998) directly assessed the impact of co-pollutants finding an effect for both $PM_{2.5}$ and strong aerosol acidity.

Another gronp of studies longitudinally assessed lung function or other measures in more complex exposure situations. For example, Mortimer et al. (2000), and Gent et al. 2003), used amhient monitoring network data to assess exposures of study subjects dispersed over relatively large areas.

In the case of Mortimer et al. (2000), all ambient monitors in the county were averaged for each of eight urban study locations, in an approach similar to that employed in daily time-series studies of mortality. Gent et al. (23003) used the average of all available ambient monitoring data in a large (6691-square-mile) study area to assess exposures. In these studies, as well as those with similar designs (Naeher et al., 1999) and exposure assessment approaches, major concerns pertain to their ability to accurately ascertain exposure to ozone relative to other co-pollutants. For example, neither design considers exposure heterogeneity within the study area, although it is well known that ozone concentrations will, for example, be reduced in areas with high traffic density due to quenching by NO emissions. Similarly, these designs also do not consider heterogeneity in concentrations of co-pollutants, for example due to traffic density, within the study area.

Neas et al. (1995) used an intermediate design in which a central ambient monitor assigned the same exposure to all study subjects, but with the advantage that these measurements were only applied to a relatively small study area where co-pollutant concentrations were also well characterized. In the setting for this study, Uniontown, Pennsylvania, it is likely that the central monitoring site adequately characterized exposures of the study population, although some small degree of heterogeneity in ambient concentrations is still likely to have resulted in error in characterization of exposure. Ross et al. (2002) also employed a similar approach to exposure assessment. Although implemented in a more complex exposure environment, a somewhat similar study design was that of Romieu et al. (1998) in which the study area (subjects' residence and air monitoring data) was restricted to a specific region within the Mexico City urban area.

An additional issue regarding panel studies and ozone exposure is their ability to consider time-activity patterns. Assessment of activity patterns of study subjects is important given the distinct diurnal patterns of ambient ozone concentrations. The studies of Korrick et al. (1998), Brauer et al. (1996), and Kinney et al. (1996) basically incorporate time activity patterns and the ozone diurnal concentration pattern into the design by measuring outcomes before and during/after daytime periods of elevated ozone concentrations in subjects who, by design, are outdoors during this interval. For example, Brauer et al. (1996) measured lung function before and after daylight work periods in a group of outdoor agricultural workers, Korrick et al. (1998) measured lung function before and after subjects conducted an outdoor hike, and Kinney et al. (1996) measured markers of inflammation in bronchoalveolar lavage samples collected before and after subjects exercised outdoors. Neas et al. (1995), while using central-site ambient monitoring data to assign exposures, also collected individual level data on time-activity patterns and calculated weights to develop individual exposure estimates based upon the proportion of daytime hours spent outdoors. When comparing the weighted versus un-weighted (assuming all children spent the same amount of time outdoors) associations, ozone for peak expiratory flow and evening cough were larger than un-weighted effect estimates. These findings indicate the importance of incorporating time-activity patterns in study design and suggest that failure to adjust for individual-level differences in time-activity patterns, as in the majority of studies using central or averaged monitors (Gent et al., 2003; Mortimer et al., 2000; Naeher et al., 1999; Romieu et al., 1998; Ross et al., 2002), may result in smaller effect estimates.

Panel studies may provide an opportunity to examine ozone exposure and specific parameters of disease activity. For example, Gent et al. (2003) followed 271 asthmatic children under age 12 over 6 months for daily symptoms in relation to ozone and PM$_{2.5}$ The need for regular antiasthma medication was considered an indicator for more severe asthma. Not taking any medication on a regular basis and not requiring a bronchodilator suggested the presence of mild asthma. The ozone effects observed in relation to symptoms were seen only in the medication group. Although the medication use provides an attractive index of disease activity, Gent et al. (2003) did not control for pollen and relative humidity that may be potential confounding factors—it is unclear if these are correlated with ozone concentrations in this study area. This represents another potential limitation of this particular study, although other studies have shown independent effects of ozone and pollen. Finally, the absence of personal monitoring, as previously discussed, is a significant limitation in terms of attributing the effects to ozone.

Controlled human exposure studies

Controlled human studies, or clinical studies, involve exposure of human volunteers to ozone and/or other pollutants under carefully controlled conditions, usually in an exposure chamber, but occasionally via face mask. Activity patterns during exposure are usually conducted according to a protocol, and measurement of minute ventilation (V_E) during exercise for each volunteer and ozone concentration (C) in the chamber during exposure allows accurate and precise calculation of personal exposure. Some noninvasive measures of response such as lung function and respiratory symptoms can be made repeatedly before, during, and after a single exposure while other, more invasive ones such as bronchoalveolar lavage (BAL) or airway reactivity can usually only be performed on one occasion for each exposure. Volunteers usually also undergo an exposure to filtered air (FA) alone, which is otherwise identical to that of the ozone exposure and which serves as a control condition. Comparison of the responses to ozone and FA exposures allows independent estimates of ozone-induced effects without confounding variables from the study itself, such as exercise or diurnal effects.

Nature of evidence

At the time that the 1996 EPA Criteria Document (1996a) was written, the following characteristics of response to ozone exposure had been well established in controlled human studies:

1) Sufficient short-term ozone exposure caused the following acute reversible effects: (1) lung function decrements (e.g., FEV_1); (2) induction of respiratory symptoms (e.g., cough, pain on deep inspiration); (3) airway epithelial injury leading to a cascade of events, including increased epithelial permeability, inflammation, and repair; and (4) increased airway reactivity to nonspecific stimuli such as methacholine.
2) These effects had all been observed to occur in a dose-response fashion down to 0.08 ppm ozone in one or more studies as a result of 6.6-h exposures with moderate, nearly continuous exercise. They had generally not been studied at concentrations below 0.08 ppm.
3) Younger adults were more responsive (for symptoms and FEV_1) than older adults. Sparse data suggested that for low-level, short-duration exposures, 8–11-year-old children experienced FEV_1 responses that were similar to those of young adults but experienced symptom responses that were absent or smaller. No controlled exposure data were available for children exposed to higher levels of ozone or for durations longer than 2 h. Response was accentuated by exercise and increased duration of response (up to 6.6 h), all other things being equal.
4) Otherwise similar, healthy young adults varied in their individual responsiveness (FEV_1 and symptoms) to ozone, but with reproducible levels of response at the individual level. The observed interindividual variability in response became more pronounced and the distribution of individual responses more skewed at higher and higher exposures (i.e., which produced larger mean effects).
5) Multiday exposures resulted in an attenuation of the FEV_1 and symptom responses after 3–5 days of exposure, and this attenuation of response lasted for several days to 2 weeks following 5 days of exposure. Other less well-established data suggested that the acute reversible FEV_1 responses of volunteers with asthma may be marginally larger than those without asthma.

Many clinical studies published since the 1996 EPA Criteria Document (EPA, 1996a) have generally been consistent with the information that was well established at that time, and no previously well accepted finding has been refuted. Further studies on asthmatics have generally, but not uniformly, supported the earlier impression that the acute lung function response of asthmatics may be slightly greater than those without asthma. Several new observations that are described below have been made since 1996.

1. Small group mean FEV_1 responses have recently been observed following exposure to 0.06 ppm for 6.6 h in volunteers undergoing moderate, nearly continuous exercise. Over the past 10 years, Adams (2002, 2003, 2006a, 2006b) has published a series of studies of exercising young healthy adults exposed to various concentrations of ozone for 6.6 h that are comparable to the series of studies available for the EPA Criteria Document (EPA, 1996a). His findings for exposures to 0.08 and 0.12 ppm are generally similar to those of these earlier studies both with regard to mean and interindividual variability of FEV_1 response as well as with regard to respiratory symptoms.

   Adams (2006a), for the first time, however, also conducted exposures to 0.04 and 0.06 ppm ozone. There was no meaningful evidence of an effect during the 0.04-ppm exposures, but the data suggest that exposure to 0.06 ppm ozone does result in a small group mean FEV_1 decrement relative to FA exposure, but with ambiguous statistical significance. In this study (Adams, 2006a), 30 healthy young individuals were exposed for 6.6 h to six conditions, including filtered air, 0.06 ppm, and 0.08 ppm, among others. Adams (2006a), seeking differences in patterns of response among the different exposures, utilized a Scheffe post hoc test for controlling study-wide level of alpha while making multiple comparisons among the many data points. This test (which is not particularly powerful for detecting specific differences in the context of large numbers of comparisons) did not identify the response of the 0.06-ppm exposure as statistically different from that of the FA exposure. However, alternative statistical tests suggest that the observed small group mean response in FEV_1 induced by exposure to 0.06 ppm compared to FA is not the result of chance alone. The mean difference in the FEV_1 decrements between the two exposures at 6.6 h was approximately 2.9%, which was statistically different ($p < 0.001$) from 0 when tested using a t statistic without correction for multiple comparisons.

   Further examination of the postexposure FEV_1 data and mean data at other time points and concentrations also suggest a pattern of response at 0.06 ppm that is consistent with a dose-response rather than random variability. For example, the response at 5.6 h was similar to that of the postexposure 6.6-h response and appeared to also differ from the FA response. The volunteers in this study did not appear to be more responsive to ozone than volunteers in previous studies as the observed response at 0.08 ppm in this study was similar to that of previous studies. Although of much smaller magnitude, the temporal pattern of the 0.06-ppm response was generally consistent with the temporal patterns of response to higher concentrations of ozone in this and other studies. Responses below 0.08 ppm ozone have not previously been observed, but this finding is not totally unexpected because the previously observed FEV_1 responses to 0.08 ppm were in the range of 6%–9%, suggesting that exposure to lower concentrations of ozone would result in smaller, but real FEV_1 decrements. The EPA reanalysis and reinterpretation of the studies of Adams has been questioned by Adams (2007) and by Smith (2007) in presentations to the Clean Air Scientific Advisory Committee. Thus, the public health significance of responses at 0.06 ppm ozone is still being debated. The Panel recognizes that uncertainty necessarily surrounds a secondary analysis and the integration of results from a single study in one laboratory with 0.06 ppm ozone exposures and results obtained in studies at higher concentrations by other investigators. Resolution of this uncertainty will require that further research be conducted to clarify the issue. The Panel felt strongly that a double-blinded randomized study with the same subjects exposed to multiple ozone concentrations in the 0.04–0.09-ppm range, with appropriate air controls, would aid in reducing the uncertainty in exposure-response relationships below 0.08 ppm ozone.

2. Several new studies have demonstrated that exposure of individuals with atopic asthma to sufficient levels of ozone produces an increase in specific airway responsiveness to inhaled allergens. The observed responses have only been studied for ozone concentrations above the current NAAQS of 0.08 ppm. The lowest concentration at which this response was observed by Kehrl et al. (1999) following a single exposure was 0.16 ppm during 7.6-h exposures with light exercise. Four consecutive days of exposure to 0.12 ppm for 3 h (Holz et al., 2002) also resulted in an increase in responsiveness to inhaled allergen. These findings, in combination with previously observed effects of ozone on nonspecific airway responsiveness and airway inflammation, support the idea that ambient ozone exposure could result in exacerbation of asthma several days following exposure, and provides biological plausibility for the epidemiologic studies in which ambient ozone concentration has been associated with increased asthma symptoms, medication use, emergency room visits, and hospitalizations for asthma.
3. Some new evidence points to an enhanced inflammatory response in people with asthma exposed to ozone compared to people who do not have asthma (Scannell et al., 1996).
4. Holz et al. (1999) demonstrated individual variability in the inflammatory response and reproducibility of the individual differences, as is the case for FEV_1 responses. Several studies, however, have shown no correlation between the magnitude of individual FEV_1 responses and the inflammatory response, suggesting that different mechanisms are responsible for the two effects Holz et al., 1999; Balmes, et al., 1996; Torres et al., 1997).
5. Evidence suggests that although multiple daily exposures result in attenuation of the FEV_1 and symptom effects for subsequent exposures, some of the epithelial damage/inflammation/epithelial permeability responses do not attenuate during a 5-day exposure (Devlin et al., 1997; Jorres et al., 2000).
6. One study (Folinsbee et al., 1994) suggests that nonspecific airway responsiveness to methacholine does not completely attenuate after 4–5 days of prolonged ozone exposure.
7. One study (Frank et al., 2001) suggests that multiple daily exposures to ozone results in persistent functional small airway changes reflected in lower baseline levels of small airway function over time.
8. Several studies (Adams, 2003, 2006a, 2006b) have confirmed an earlier report (Hazucha et al., 1992) that hour-by-hour responses to prolonged exposures with triangular concentration patterns are not adequately described by the responses to constant concentration exposures with the same overall mean concentration. Rather, responses at intermediate time points are influenced by recent peak concentrations. New exposure-response models based upon a differential equation and a logistic (sigmoid-shaped) function have been developed which accurately describe this hourly FEV_1 response to a wide range of exposure conditions for both constant and variable concentration and activity pattern exposures (Smith et al., 1999; McDonnell et al., 2007). The predictive ability of these models in independent data sets has not been assessed.
9. One study (Gong et al., 1998) found relatively small effects of ozone on several indices of cardiovascular (CV) function among many measured. Responses were similar for volunteers with no CV disease and those with essential hypertension. This is a relatively unexplored area, and the implications of the results of this study for explaining potential CV effects of ambient ozone on the general population are unknown.

Special considerations in evaluating controlled human exposure studies

Controlled human studies are powerful tools for assessing acute, reversible health effects of short-term air pollutant exposure. Because of the random assignment of volunteers to treatment group or the randomization of the order of treatment in a crossover study design, these studies are experimental in design and associations observed in controlled human studies can be considered causal in nature, unlike observational studies in which concerns about confounding and other forms of bias are usually present. Because ozone concentration and minute volume can be measured for each individual, accurate and precise estimates of personal exposure are available for estimating the quantitative relationship between exposure and response. The resulting exposure-response models more accurately reflect true causal relationships, improving risk assessment.

Because pollutant concentrations in a chamber can be controlled, the effects of ozone can be studied directly and independently of the effects of other pollutants in the photochemical mixture that occurs in the ambient air. For logistic reasons (e.g., small sample sizes), these studies are limited in their ability to detect causal effects of ozone on relatively rare, but potentially important events (e.g., emergency room visits for asthma exacerbation). Furthermore, for ethical reasons some segments of the population most likely to be sensitive to ozone exposure (e.g., people with severe asthma) or of great public health concern (e.g., children) are more difficult to study. In these cases, however, controlled human studies can often provide information that complements or enhances the interpretation of findings in observational studies. The best illustration of this is investigating whether ambient ozone exposure causes or contributes to asthma exacerbation, which controlled human studies cannot directly address. Although people with asthma at greatest risk cannot be subjected to experiments, studies of people with mild asthma reveal that ozone exposure increases airway inflammation and epithelial permeability, nonspecific airway reactivity, and airway responsiveness to inhaled antigen. Because airway inflammation is a hallmark of asthma, increased nonspecific airway responsiveness is associated with elevated likelihood of asthma exacerbation, and increased responsiveness to inhaled antigen is a direct mechanism of exacerbation, the results of these clinical studies indicate that it is biologically plausible that ozone exposure can contribute to asthma exacerbation. These findings support observational studies that associate ambient ozone concentration with asthma exacerbation.

Mechanisms of ozone toxicity

Ozone affects the human respiratory system in several ways. Ozone is a highly reactive gas that is deposited throughout the entire respiratory tract from the airways to the alveoli. Its solubility in water is greater than that of oxygen and its oxidant nature renders it able to react with almost any biomolecule along the respiratory tract. The solubility and reactivity likely account for the reported approximately 40% uptake of inspired ozone by the human nasopharynx (in contrast to SO_2, which is >98%). Dosimetry models predict that the tissue dose of inhaled ozone is greatest at the bronchoalveolar junction, which is the pulmonary region experimentally most sensitive to ozone. Recent ozone bolus studies in humans have confirmed that inspired ozone reaches the distal airways and alveoli of sedentary volunteers, and during exercise ozone penetrates deeper and in greater amounts to the distal lung regions. Thus, ozone can affect the entire respiratory tract but maneuvers such as exercise or oral breathing alter regional deposition of the gas.

Toxicity of ozone is primarily attributed to its reactivity and ozonation of unsaturated fatty acids present in lung lining fluids. Controlled exposure studies in animals and humans have provided a strong scientific basis for understanding ozone toxicity. Changes in lung function in response to ozone have been studied in healthy volunteers, people with asthma, and in individuals with chronic obstructive lung disease, as well as in a number of animal models.

In addition to effects on pulmonary mechanics, exposure to ozone at levels near the current NAAQS causes cellular and biochemical changes in the upper and lower respiratory tracts characteristic of an acute inflammatory response. Respiratory tract inflammation and increased cellular permeability are two of the best-studied biological markers of ozone-induced mechanisms of lung injury in animals, including humans. Clinical studies using BAL show ozone-induced increases in polymorphonuclear leukocytes (PMNs), soluble markers of inflammation and repair, and markers of epithelial permeability (Seltzer et al., 1986; Kehrl et al., 1987; Koren et al., 1989; Devlin et al., 1991; Frampton et al., 1997). Soluble mediators of inflammation (e.g., the cytokines interleukin [IL]-6 and IL-8) as well as arachidonic acid metabolites (e.g., prostaglandin E2 [PGE2], PGF2α, thromboxane, and leukotrienes [LTs] such as LTB4) measured in the BAL fluid in humans exposed to ozone also have bronchoconstrictive properties and may be involved in increased airway responsiveness following ozone exposure.

Animal and human studies suggest that genetic factors can play a major role in responsiveness to ozone. Mice exhibit large intrastrain differences in response to ozone, and a genetic locus confers susceptibility to the ozone-induced influx of PMNs into the lung. Recent evidence suggests that single-nucleotide polymorphisms or null alleles may be risk factors for various diseases. Because ozone is a strong oxidant, it is plausible that genetic variations in phase II antioxidant genes, such as glutathione *S*-transferase, could increase ozone responsiveness. For example, children with an absent or nonfunctioning glutathione *S*-transferase Mu-1 (GSTM1) allele living in Mexico City had greater ozone-induced lung function changes than GSTM1-positive children. Tissue biopsies from GSTM1-null individuals were exposed to ozone in vitro and had significantly increased superoxide dismutase (SOD) expression compared to biopsies from individuals with the wild-type allele. Similarly, chamber studies appear to be demonstrating enhanced responsiveness among GSTM1 ozone-exposed individuals.

In summary, the mechanisms of ozone toxicity in producing relatively acute effects are well understood. The dose to the target tissue, injury to the epithelium with resultant inflammation and increased permeability, and genetic polymorphisms that may confer susceptibility are likely interrelated. These animal and clinical laboratory findings provide plausibility for ozone exposure producing the effects reported in the field and epidemiological studies. However, the laboratory responses are (1) typically observed at levels exceeding those found in the environment; (2) are rapidly reversible; (3) indicate a different mechanism of injury for the inflammatory and functional effects based on disparate responses; (4) are not always unique to ozone, other common air pollutants act through similar mechanisms; and (5) offer little direct insight into potential chronic health effects secondary to ozone exposure.

The most relevant experimental evidence on the effects of chronic exposure to ozone comes from a series of interrelated studies conducted under the sponsorship of the National Toxicology Program (NTP) and the Health Effects Institute (HEI). The exposures were conducted at the Pacific Northwest Laboratories (PNL) of the Battelle Memorial Institute and included experimental observations made by PNL scientists conforming to the standard NTP bioassay. In addition to the observations made by PNL scientists, HEI-supported scientists from other institutions made additional observations that focused on noncancer endpoints in respiratory tract tissue ranging from the biochemical level to studies of pulmonary function. F344/N rats and B6C3F$_1$ mice, of both genders, were exposed to ozone starting at 6 weeks of age for up to 125 weeks (rats) and 130 weeks (mice). The exposure levels were 0, 0.12, 0.5, and 1.0 ppm ozone for 6 h/day, 5 days/week. The highest concentration was viewed as being the highest concentration that could be tolerated with prolonged exposure.

The details of the studies are documented in reports by the NTP (NTP, 1994) and HEI (Boorman et al., 1995; Harkema et al., 1994; Catalano et al., 1995). The HEI reports are rigorously peer-reviewed and are much more detailed than typical open-literature publications. The three HEI reports cited provide an overview and key results of the ozone studies, there are additional eight reports available. They may be found on the HEI Web site. The survival of both rats and mice were generally similar for all groups. Body weights were generally similar across all groups of rats and mice, with an indication of hypoactivity and lower body weights with the highest ozone exposure concentrations. The most pronounced histological changes, metaplasia and hyperplasia, were observed in the nasal tissues of both rats and mice. There was no effect of 0.12 ppm ozone on nasal structure or function. Alveolar epithelial metaplasia and interstitial fibrosis in the lung were observed with ozone exposure. The pulmonary pathology present with exposure to 0.5 ppm and 1.0 ppm ozone was not present at the 0.12-ppm exposure level. There was no increase in neoplasms in either rats or mice associated with ozone exposure. Extensive pulmonary function tests, similar to the research methods used in human clinical studies, were conducted on the rats. The ozone exposure had little or no measurable impact on lung function. The investigators hypothesized that with prolonged exposure the animals became tolerant to the injurious effects of ozone.

The findings in the mice and rats exposed for prolonged periods of time, approximating the life spans of the two species, to high concentrations of ozone complement the extensive observations with short-term exposures that have tended to focus on acute effects. Species differences in the disposition of inhaled ozone are well recognized and must be considered in extrapolating the findings in mice and rats to humans. In addition, despite the general qualitative similarity of toxicity of many chemicals in laboratory animals and humans, the question remains as to the extent the findings in the mice and rats can be quantitatively extrapolated to humans.

Risk assessment

The risk assessment process

Risk assessment is the process by which analysts summarize the available evidence on health effects in terms that are relevant for policy making. In most applications, including for EPA's NAAQS setting process, the risk assessment is *quantitative*, meaning that the policy-relevant outputs of the risk assessment are numerical estimates of specific health impacts. Risk assessment is the first point in the chain of scientific inquiry on pollutant health effects where analysts take the evidence from clinical and epidemiological studies of responses or associations to estimate implications for the population at large under alternative air quality standards. This requires a number of extrapolations, simplifications, and policy judgments that imply large overall uncertainty in the resulting assessment. As the NRC (2002) has advised, "Although the results of benefit analysis may appear to be less certain, EPA should describe the uncertainty as completely and realistically as possible, recognizing that regulatory action might be necessary in the presence of substantial uncertainty."

A very major shift in the nature of the discussion of the scientific evidence occurs at the risk assessment step. Most of the deliberations surrounding interpretation of the health effects literature center on the question of "whether" certain studies indicate a particular type of physiological response to exposure, and whether an observed response has medical significance. In the risk assessment step, however, EPA treats the question of "whether" as resolved in favor of "yes," and shifts to the question of "how much" public health response occurs and how much those impacts could be reduced by changing the NAAQS. Thus, while much debate continues on whether a causal relationship between ozone and premature mortality lies beneath the studies that have detected a statistical association between the two, EPA's risk assessment presumes this to be the case for the sake of making its numerical estimates. EPA notes this presumption in its documents, but the fact is easily lost to those who do not read the source documents in full, but do read the summaries of the numerical estimates of "lives lost" and potential "lives saved" by tightening the NAAQS.

The resulting numerical health effects estimates are supposed to synthesize and be consistent with all of the available evidence, which may be a combination of toxicological, clinical, and epidemiological studies. In practice, however, most of EPA's risk assessment results are merely extrapolations from a single type of study. In the case of ozone, the estimates of premature mortality and hospitalizations—which are given the greatest focus in subsequent policy-making deliberations—are extrapolated from just a few specific epidemiological studies. The uncertainties introduced in the many types of extrapolation that occur in risk assessment will be discussed below, after a brief summary of the mathematical procedure that EPA employs to extrapolate from epidemiological studies to its estimates of health effects.

An epidemiological study reports whether it detected an association between rates or incidences of a particular health effect (e.g., mortality or hospitalization) and levels of ambient pollution. Actually, there is always some kind of association detected, and the question of interest is whether the numerical estimate of the association is positive (i.e., health effects tended to increase as pollution increased), and what the confidence interval (i.e., the range of variability) is around that numerical estimate. The numerical estimate is often reported as a relative change in risk for a particular amount of change in the monitored ambient pollutant levels, where a relative risk greater than 1.0 implies that the observed association is positive. A "statistically significant" positive association is one where the confidence range for the numerical estimate of relative risk is always greater than 1.0. Often positive associations are reported as evidence of a health effect, yet such estimates are not statistically significant, which means that the probability that the estimated association is actually negative exceeds the specified confidence level (usually 2.5%). The degree of insignificance can be so large that the probability of the association being negative may reach 50% whereas the point estimate of the risk coefficient remains positive. Nevertheless, EPA uses such nonsignificant associations to generate positive point estimates of health effects from ambient pollution, and of public health gains by tightening the ambient standard.

In the risk assessment, EPA takes the numerical estimate of the association from a particular epidemiological study and interprets that numerical estimate as the slope of a "concentration-response" function for the population at large. The concentration-response function provides an estimate of the health effects risk level of an entire population (e.g., the population of a metropolitan area) when exposed to different levels of a specific measure of ambient air pollution. The pollutant metric used in the concentration-response function is the same as the one measured in the original study (e.g., in terms of the daily average ozone concentration measured at a particular set of monitors in the case of daily ozone mortality studies). Because of the particular shape of the concentration-response relationship that EPA employs, EPA assumes that the change in population risk per unit change in ambient concentrations will be the same at much lower concentrations as it was for the particular levels of pollution that were present at the time the study was conducted. Notably, the concentration-response function also assumes that the level of population risk will be the same for any mix of air pollution that may coexist with a particular value of the single pollutant metric used in the concentration-response function.

EPA then uses recently monitored daily average concentrations of ozone for a specific city to estimate the level of health effects on each day in that city by calculating the "response" level projected by the concentration-response function for each day's ozone level. Daily effects estimates are summed over a full ozone season of daily ozone concentrations to obtain its reported ozone season health effects incidence levels. These estimates are compared to estimates at different levels of pollution, including an estimate of "background" levels, and at estimates of ambient concentrations that would hypothetically occur under alternative NAAQS levels. For the NAAQS standard-setting deliberations, EPA prepares risk estimates only for a selected set of cities, ostensibly because EPA does not wish to extrapolate health effects associations estimated in one particular location (i.e., with a particular socioeconomic mix, weather and lifestyle patterns, and pollutant mixtures) to other locations. In practice, however, EPA makes such extrapolations anyway in how it established the concentration-response functions that it uses for the cities that it does include in its risk assessment. (For example, EPA relies on mortality relative risk estimates for each city included in its risk assessment that were developed as national estimates, using data from a multitude of cities.)

Uncertainty exists in the results of the original studies, but the risk assessment process, which extrapolates from the samples in the studies to a broader population, adds substantially to it—even if that broader population is limited to people in the same location or with the same health conditions as in the sample of the study. The extrapolations required in risk assessment introduce three broad categories of additional uncertainty: (1) extrapolations made to estimate exposure-response relationships, (2) extrapolations made to assess changes in exposures, and (3) policy judgments made regarding "background" pollutant concentrations.

Uncertainty in estimating ambient concentration-response relationships

Uncertainties of the first category—those due to extrapolating from epidemiological evidence to develop a quantified "exposure-response relationship"—have received the lion's share of attention in reviews of EPA's risk assessment. This focus is not because this is the largest source of uncertainty. It is probably because the associated issues are most closely related to the health effects literature, the area in which most of the commentors and advisors surrounding a NAAQS review are experts. The uncertainties are, nevertheless, very large. The discussion of the risk assessment calculations above has already mentioned some of the following extrapolation issues: (1) from the populations in the original studies to current populations in the United States; (2) from levels of pollutants in the original study to current and hypothetical lower levels of concentrations (particularly down to levels that were never experienced in the course of the original study); (3) from the pollutant mix present at the time and place of the original study to the pollutant mix that would be present at different times and locations; and (4) from changes in monitored average concentrations across wide geographical areas to changes in the exposures actually experienced by individuals

In addition, of course, is the fact that the analysis assumes that statistical associations (sometimes statistically nonsignificant ones) reflect a causal relationship with the specific pollutant of concern (i.e., ozone in this case).

Extrapolation is not the only source of uncertainty in developing a quantitative representation of an exposure-response relationship based on epidemiological evidence. As an aside, exposure data for large populations is never available so it is necessary to assess the ambient concentration-response relationship. There are also concerns with quantitative biases in the epidemiological estimates of the relative risk. If a relative risk is estimated for a single pollutant, yet two or more pollutants are affecting health outcomes, then the relative risk for the single pollutant formulation may actually reflect the combined impact of other pollutants that are missing from the statistical model. If they are both exerting an effect, and both pollutants are positively correlated, the relative risk for the single pollutant in question may be overstated. In fact, a positive relative risk could be attributed to a pollutant that is having no effect on health at all if it is correlated to a harmful exposure that is never included in the regression. Similarly, estimates of relative risk have been shown to vary quite substantially when the statistical model controls for weather and other temporal factors in different ways. There is no objective way to determine the correct form for these statistical controls, so that one has no way of knowing which of the many possible relative risk estimates is the best one—and thus, whenever any single estimate is used in the risk assessment, it is almost certainly a biased estimate.

All of the above concerns in how to move from a qualitative interpretation of the epidemiological literature to the quantitative interpretation required in risk assessment contribute to "model uncertainty." This form of uncertainty is distinct and separate from the statistical variability that surrounds the relative risks that are estimated in the epidemiological studies. Whereas there is statistical variability about the magnitude of the relative risk that is estimated using a particular statistical formula with a specific combination of explanatory variables (or model), model uncertainty relates our lack of knowledge of how to choose the best statistical formula, and also the inherent inability of the statistical techniques to inform us about the shape of the true underlying exposure-response relationship. For example, the statistical techniques and data are limited in their ability to distinguish whether the relative risk per unit of additional concentration varies from lower to higher exposures within the observed data. It is, of course, impossible for these methods to determine such functional shape at levels of exposure that are substantially below those in the dataset—but which are not below those being considered in the risk assessment. Even if the question of functional shape could be addressed satisfactorily for the concentration-response relationship, model uncertainty remains due to the question of how the observed changes in ambient concentrations translate into changes in exposures that people actually experience. All of these issues thus imply a large swath of uncertainty that the measure of statistical variability from the original study does not reflect at all.

Sensitivity analyses—both in the epidemiological estimations and by risk analysts considering alternative extrapolations from estimates in the literature—indicate that model uncertainty regarding the choice of statistical formulation and shape of the ambient concentration-response relationship is much larger than the statistical uncertainty surrounding relative risk estimates obtained for any particular statistical formulation using a single set of data. In practice, however, EPA ignores model uncertainty in its primary risk estimates. EPA presents its primary risk estimate with a "confidence range" that appears to be a statement of uncertainty about its health effects incidence estimates; however, this range reflects only the statistical variability reported for the single relative risk estimate that EPA has chosen to rely on.

Uncertainty in estimating changes in ozone exposures

The second category of uncertainty that is inherent in the extrapolations in EPA's risk assessments for setting a NAAQS is much less widely recognized, but is just as important quantitatively. This is the extrapolation that EPA makes to assess how exposures will be changed if EPA tightens the NAAQS. The way that an alternative standard could reduce health risk is by changing exposure levels, at least on some days. In its risk assessment, therefore, EPA has to estimate how and when exposure levels would change as a result of imposing a different NAAQS level or form of standard. This requires important policy judgments described below. EPA's resulting risk estimates are very sensitive to these judgments.

First, because the risk assessment uses only a concentration-response function, it assumes that all individual exposures change in direct proportion to ambient concentrations at a fixed set of area-wide monitors. Thus, to simulate the change in risks under an alternative standard, EPA estimates how attainment of that standard would affect currently measured average ambient concentrations on the existing network of monitors in each metropolitan area in its risk assessment. The extrapolation technique that EPA applies is called the "rollback" method, because it takes a record of previously monitored ambient levels (e.g., all of the monitored hourly ozone values taken in the city being analyzed during the 2004 ozone season) and lowers ("rolls back") each monitored value by a specific proportion.

In the case of ozone, EPA determines the proportion by which each monitored value in the record is reduced, or rolled back, by estimating the percentage by which the highest values within that record would have to be reduced in order to "just attain" the alternative standard. A related percentage reduction is then applied to every other hourly monitored value in the record, depending on the absolute level of ozone that was measured. The percentage reduction applied to these highest values in the distribution of hourly measurements is simply the initial percentage reduction that EPA determined necessary for attainment. As one moves to lower and lower levels on the distribution, that initial percentage is reduced gradually in such a way that it becomes a zero-percentage reduction just as one reaches the tail of the distribution where the measured ozone level would be zero. EPA calls this a "quadratic rollback" formula because the initial rollback percentage declines in a quadratic fashion along the length of the distribution that is being rolled back. The end result is a new distribution of hourly ozone values that lies to the left of the original actually monitored distribution, with greater reductions on the higher ozone days than on the lower ozone days, but always with quite substantial reductions until one reaches near-zero ozone values.

The new distribution exactly meets the alternative standard in question in terms of its peak levels, but use of EPA's rollback formula also makes a strong assumption in its adopted rollback formula that attainment of the necessary peak conditions will have a very substantial effect on ozone exposures in every single hour of the ozone season. Figure 7 provides an example of the distribution of ozone values in

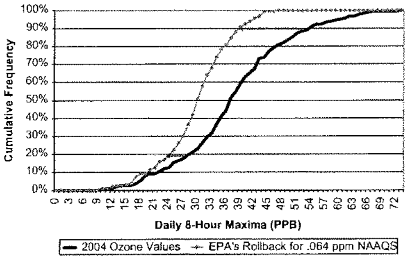

Figure 7. Cumulative distribution function for Detroit 2004 ozone, and distribution after EPA's rollback to simulate "just attaining" a 0.064-ppm ozone NAAQS. (See colour version of this figure online at www.informapharmascience.com/iht)

2004 in Detroit, and of what EPA assumes for its risk assessment would be the distribution of ozone concentrations if Detroit were to just attain an alternative standard of 64 ppb. At each point moving up the graph vertically (which is like moving from the lowest percentile of hourly concentrations to the highest percentile), EPA's estimates of health effects on days at each concentration level are decreased in proportion to the horizontal distance between the original and extrapolated curve.

The total reduction in estimated health effects is (effectively) proportional to the sum of the reductions at each concentration level. For example, consider the 20th percentile concentration level in Figure 7 (i.e., a concentration that is exceeded 80% of the days). The 8-h maximum in 2004 in Figure 7 was about 28 ppb. EPA's rollback method assumes that a NAAQS of 64 ppb would cause all days already at about 28 ppb to be reduced to about 24 ppb. If background levels are assumed to be 20 ppb, this is a 50% reduction, and the portion of risk above background associated with days at that level will also fall by about 50%. Similarly, for days at the 90th percentile ozone levels, the 2004 concentration in Figure 1 was about 53 ppb. EPA assumes concentrations at this level will be reduced to about 38 ppb. If background is 20 ppb, the estimated risk associated with this higher concentration would be reduced by about 45%.

With this knowledge of how the rollback assumptions determine the estimated risk reduction from tightening the standard, one can observe that a large majority of the health effects reductions that EPA has assessed for tightening the ozone standard will be attributable to quite large proportional reductions in ozone in hours when ozone is actually quite low (e.g., almost 90% of the 2004 monitored 8-h average ozone concentrations were less than 50 ppb).

It should be noted here that EPA does not actually compute any benefits for changes in ozone below a value that it calls "Policy Relevant Background," even though it does perform the rollback over all values as shown in Figure 7. The assumption about policy relevant background adds another very important component of uncertainty to EPA's risk estimates and is discussed later. However, regardless of the assumption about Policy Relevant Background, it should be apparent that the assumptions made for using a record of observed ozone concentrations to estimate the pattern of concentrations that would occur under an alternative standard can have an extremely significant impact on the benefits that EPA estimates for such alternative standards. To illustrate this uncertainty further, imagine that an attainment strategy is found that would significantly reduce only the extremely high ozone peaks, such as the highest 5% of the 8-h peak values.

This strategy would also allow the alternative standard to be met. If such a strategy were to be implemented, then the only part of the black line in Figure 7 that would shift as a result of attaining the tighter standard would be the very top segment that lies in the vertical range from 95% to 100%. The rest of the green line in the range from 0% to 95% would lie directly over the black line. Thus, all of the estimates of risk reductions in the lower 95% of the distribution would be eliminated. As a result, estimates of the risk reductions that the alternative standard would provide would be much smaller than EPA has estimated using its assumed quadratic rollback formula. This example is not intended to imply that such an extreme "peak shaving" strategy can be expected in most cases; it is only offered to highlight just how strongly the EPA risk estimates depend on the particular rollback assumptions that it chooses. There is just as much uncertainty in the estimates of risk associated with different possible rollback assumptions (all of which would be consistent with attaining alternative NAAQS standards) as there is uncertainty in the shape and level of the exposure-response curve. This rollback assumption uncertainty is rarely discussed and deserves much more scrutiny in policy deliberations.

Uncertainty associated with EPA's assumption on "Policy Relevant Background"

A third category of uncertainty in the results of EPA's risk assessment for ozone relates to a seemingly innocuous assumption in its risk assessment calculation. EPA calculates and reports risks that are attributable to ozone above the Policy Relevant Background (PRB). The determination of what PRB actually is, however, is extremely difficult. Importantly, uncertainty and debate about the correct PRB value is the single most critical source of uncertainty in the current set of EPA ozone risk estimates. EPA has changed its estimate of PRB since the last ozone review cycle. In 1997, EPA assumed that PRB was 40 ppb throughout the ozone season. In the current review cycle, EPA has estimated PRB for each city using GEOS-CHEM. The new PRB estimates, which vary temporally and by city, are substantially lower than 40 ppb. For example, the maximum hourly value of PRB that EPA now uses for Detroit is 27 ppb, and the seasonal average value over all the hours is only 21 ppb, or approximately half of what it assumed for its 1997 analysis.

EPA changed its PRB assumption with relatively little discussion, but EPA's current estimates of mortality health benefits from tightening the NAAQS depend almost entirely on this seemingly minor change of assumption about PRB. For example, EPA estimates 24 premature deaths per year in Detroit due to the extent to which its 2004 ("current") ozone concentrations exceed PRB. However, if EPA had used 40 ppb as the PRB assumption, as it did in 1997, it would have estimated less than 0.1 premature deaths per year. (A similar degree of sensitivity applies to risk estimates in the other cities in EPA's risk analysis.) The change in the estimate has nothing to do with uncertainty in the ambient concentration-response relationship, but only because EPA changed this single policy judgment in its risk assessment formula.

It is beyond the scope of this review to determine what the most appropriate assumption for PRB would be; however, the technical and policy debate on what ought to be considered a "policy-relevant" minimum—or the concentrations below which NAAQS policy could not be expected to have any impact—continues to include levels of 40 ppb and even higher. The fact that key health risks associated with ozone (i.e., mortality and hospital admissions) may fall to effectively zero for PRB assumptions within this range of uncertainty reflects a critical source of uncertainty that should be highlighted and not hidden in the communication of risk analysis results. What this really implies is that the sensitivity to the PRB assumption merits further explanation. It more fundamentally reveals that almost all of the health effects that are reported in EPA's risk assessment are attributable to assumed rollbacks in the lower and middle portions of the seasonal distribution of ozone levels. When considering the heath effects that EPA claims could be avoided by applying tighter standards to peak levels of ozone, some individuals logically conclude that those benefits would be due to reductions in exposures to the peak levels of ozone. The sensitivity analysis shows, however, that extremely few of the estimated ozone health impacts are associated with days that have ozone concentrations above the current standard. Thus, for the benefits that EPA's Risk Assessment reports to occur, one must accept two strong but unsubstantiated assumptions that are inherent in EPA's risk assessment methodology: (1) one must accept that EPA's rollback assumption that ozone concentrations will be reduced substantially even on moderate and low ozone days as a result of a standard whose form addresses only the peak days; and (2) one must accept EPA's assumption that the relative risks estimated for higher levels of ozone apply *in equal degree* to changes in exposure to very low levels of ozone.

The foregoing discussion indicates that EPA should communicate more than just its quantitative estimates of health effects. It should also clearly identify the concentrations of ozone that account for the bulk of those estimates and the assumptions about the types of changes in those concentrations that EPA is assuming when it calculates its estimates of the health effects benefits of tightening the current NAAQS.

Need for integrated uncertainty analysis

The difficulties with the way assumptions about PRB affect EPA's risk estimates are just one aspect of a high degree of uncertainty about the magnitude of EPA's risk estimates. In the case of the PRB assumption, almost all of the possible alternative assumptions would lead to very much lower risk estimates. This implies that the uncertainty is not symmetric in both directions around EPA's estimate, but with a systematic bias toward overestimation in EPA's estimates. There are many other important areas of uncertainty in EPA's risk estimates that are also not properly presented or integrated into the analysis, and this fact is another serious concern with EPA's Risk Assessment method.

EPA separates its risk calculations into "primary" and "secondary" risk estimates. Only the primary risk estimates are carried forward into the summary tables of the Staff Paper and other materials likely to be read by the policy community at large, or presented to decision makers such as the Administrator. The primary estimates are calculated using a relative risk coefficient estimated based on a single regression formulation in a single epidemiological study. EPA sometimes reports "confidence bounds" or "uncertainty intervals" for these primary estimates, but *these ranges are based solely on the standard error of that single relative risk coefficient estimate.* In other words, EPA presents a measure of variability as if it were a measure of uncertainty. This may be misleading, especially to a nontechnical audience that may not take the time to learn all of the details of EPA's analysis methods. Thus, it is quite possible that some individuals will believe that these ranges are a reasonably complete representation of the uncertainties about the level of risk. Given that some of these ranges are very wide (in many cases falling into the negative numbers), it would be quite understandable if some individuals were to think these ranges present a comprehensive view of uncertainty, but they do not even start to do so.

As an earlier part of this article has explained, variability is only one very small part of the issue. Uncertainty is what we do not know at all, and which the available data cannot inform. The key uncertainties that EPA does not include in any of the risk estimate ranges that it provides include (1) *Model selection bias* caused by (a) the fact that authors report only one or two of their statistical estimates, and evidence indicates that what is left on the cutting room floor is often of smaller magnitude or less statistical significance; (b) publication bias, wherein studies that find health effects associations are more likely to be published than those that fail to find an effect; (c) EPA's selection of a single paper on which to base its risk estimate; (d) EPA's selection of a single regression from that paper even if the paper reports several. In the case of (d), EPA's pattern has been to select a risk estimate that is the largest and/or most significant from a paper, regardless of the quality of the controls that have been applied to obtain that particular result. For example, EPA uses only risk coefficients from one-pollutant formulations even if a paper contains a two-pollutant formulation. This practice creates a "missing variable bias" that leads to overstatement of the risk; (2) *Model uncertainty* caused by issues such as (a) uncertainty on how to properly control for the confounding effects of time and weather patterns when making statistical estimates of air pollution associations with health; (b) what the shape of the exposure-response function is given that the risk coefficients are estimated using blunt and noisy ambient concentration-response data; and (3) *Causality*. Even if a positive risk estimate results from many studies, there is still the question of whether any of those associations are evidence of a truly causal effect with ozone such that if ozone were reduced then the health effects that are correlated with ozone will also be reduced. The entire risk assessment starts with a presumption that there is a causal effect, but that does not mean that this is no longer a part of the overall uncertainty in the estimated effects. This is a particularly serious problem for risk estimates that are based entirely on epidemiological evidence rather than clinical evidence, which includes all of the mortality and hospitalization estimates for ozone.

Some, but not all, of the above sources of uncertainty are explored in EPA's "secondary" risk analyses, which are essentially a large volume of impenetrable sensitivity analyses placed in technical support documents and their appendices. The important thing, however, is not to "do" such sensitivity analyses, but rather to use sensitivity analyses to identify key sources of uncertainty and then to *integrate these uncertainties into a single probability distribution over the final, summary risk estimate*. The NRC review of EPA's risk analysis methodology (NRC, 2002) strongly advised that EPA provide primary risk estimates that are founded on such an integrated uncertainty analysis. The ozone risk assessment reflects no such change in approach. This stands as a significant flaw in the credibility of the resulting estimates and their appropriateness as information to support policy decisions.

Just the listing of the key sources of uncertainty provided above suggests that their preponderant effect is to create an upward bias in EPA's risk estimates. Even when leaving aside the uncertainty about causality, analyses produced by other researchers have demonstrated that when an integrated uncertainty analysis is performed, the large majority of probability in the estimates falls far below the primary estimates that EPA reports.

Summary

This paper summarizes critical considerations in evaluating scientific evidence on the health effects of ambient ozone that informed the EPA Administrator's judgment in revising the National Ambient Air Quality Standard from 0.08 ppm to 0.075 ppm with an 8-h averaging time. It is our opinion that these issues will also dominate the next review of the ozone health standard that has just been initiated.

Ozone in ambient air is produced by complex chemical processes from precursors, hydrocarbons, and nitrogen oxides emitted from both natural and man-made sources. Ambient ozone concentrations are also influenced by lightning and periodic intrusions of stratospheric ozone into the troposphere. Ambient ozone concentrations vary by time of day, season, and location across the country. The specific concentrations found at a given location are due to multiple factors, including the concentrations of precursors and other chemicals in the air originating from both biogenic and anthropogenic origins, intensity of solar radiation, temperature and meteorological conditions, both near the monitoring site and at upwind locations that influence the formation, degradation, and transport of ozone. Since promulgation of the original NAAQS in 1971, initially with a 1-h averaging time and since 1997 with an 8-h averaging time, most cities in the United States have made remarkable progress in substantially reducing ambient concentrations of ozone and other criteria pollutants by controlling man-made sources. On average across the United States, the 8-h maximum ozone concentrations have decreased by 21% and the 1-h maximum ozone concentrations have decreased by 29%. As ambient concentrations of ozone decline, the fraction of remaining ozone associated with precursors that are man-made U.S. emissions, the only part that U.S. policy can control, is reduced. This makes further reductions in ambient ozone a challenge in many areas of the United States.

To describe background levels of ozone for making policy judgments on the setting of the NAAQS for ozone, EPA has defined the "Policy Relevant Background" (PRB) as the ozone concentrations that would be observed in the United States in the absence of anthropogenic emissions of precursors (e.g., VOC, NO_2, and CO) in the United States, Canada, and Mexico. The GEOS-CHEM model used to estimate PRB has both low temporal and spatial resolution. Spatial resolution is based on a 2-degree by 2.5-degree grid, which is equal to 138 miles by 173 miles or 24,000 square miles, an area about half the size of the Commonwealth of Pennsylvania. This low resolution raises serious questions as to the relevance of modeled concentrations to actual concentrations of ambient ozone for specific regulated communities. Assumptions made about the Policy Relevant Background have important implications for interpreting the risk assessment for ozone and the extent to which the standard can be attained by control of U.S. man-made emissions. The Panel is of the opinion that there are alternative approaches to describing background ozone concentrations when making policy judgments on the NAAQS for ozone.

Data on the potential health effects of exposure to ambient levels of ozone that should inform policy judgments on the NAAQS are from five types of studies: human clinical studies, three kinds of epidemiological studies, and toxicological studies. The interpretations of these studies are a matter of debate.

The human clinical studies conducted with controlled ozone exposures of exercising human volunteers provide useful information on changes in respiratory function. There is clear evidence of temporary functional changes after protracted exposure to ozone at concentrations of 0.08 ppm and higher. EPA's reanalysis of data from a single clinical study of 30 volunteers suggests that prolonged exposure to 0.06 ppm causes small changes in lung function in some exercising individuals. Some scientists disagree with the EPA's reanalysis and its interpretation. Although these findings have not been confirmed or replicated, the responses to 0.06 ppm ozone in that study are consistent with the presence of an exposure-response curve with responses that do not end abruptly below 0.08 ppm. The uncertainty that necessarily surrounds a secondary analysis and the integration of results from a single study in one laboratory with 0.06 ppm ozone exposures and results obtained in studies at higher concentrations by other investigators requires that further research be conducted to clarify the issue. For example, a double-blinded randomized study with the same subjects exposed to multiple ozone concentrations in the 0.04–0.09-ppm range, with appropriate air controls, would aid in reducing the uncertainty in exposure-response relationships below 0.08 ppm ozone.

Major long-term epidemiological studies have not shown an association between ozone exposure and long-term mortality. These same studies, which compare the life expectancies of groups of people living in areas with different long-term average pollutant concentrations, provided key evidence of an association between particulate matter and long-term mortality for setting the particulate matter standard.

Time-series analyses consider the association between daily fluctuations in ambient ozone concentrations and day-to-day death rates within a particular city or other locale. These analyses have yielded variable results. Statistically significant positive associations between ozone and mortality have been observed in a small minority of the single-city analyses, with no statistically significant associations observed in most cities, even though some of the studies investigated time periods that extended to several decades ago when ozone levels were much higher than they are today. The National Morbidity and Mortality Air Pollution Study used a Bayesian hierarchical analysis, which is supposed to combine information across cities in an optimal way, to analyze data from nearly 100 cities. The combined analysis of all cities did find a small statistically significant positive association between ozone exposure and mortality. However, only six of the cities showed a statistically significant association between ozone exposure and mortality. The heterogeneity of the individual city-specific results across the United States suggests that a single national ozone concentration-mortality coefficient is not appropriate and its use should be questioned. Time-series analyses have also been performed to examine the relationship between ozone exposure and hospital admissions. However, in contrast to the mortality studies, there have been very few new studies since 1997. Those that have been done imply stronger associations with other pollutants than with ozone. In the near term, it will be important to conduct updated time-series studies that extend to more recent times and, thus, include periods of improved air quality. These studies will be most useful when at least one of the ozone metrics evaluated is the current 8-h averaging time used in the ozone standard.

Panel studies typically measure specific health outcomes repeatedly for a defined group of people for short periods of time and assess how these outcomes are associated with repeated measures of an ambient air pollution mixture that contains ozone. Two studies in which personal exposure to ozone was more accurately assessed than in other panel studies observed associations between low concentrations of ambient ozone and temporary decrements in lung function in individuals engaging in strenuous activities (i.e., agricultural field workers and mountain hikers). Although associations between ambient ozone concentration and asthma status outcomes have been observed in some, but not other panel studies, less precise exposure assessment makes it more difficult to ascribe the effects to ozone with certainty. Such ozone exposure-asthma outcome relationships are, however, biologically plausible, as demonstrated at higher concentrations in controlled studies. The inclusion of an 8-h averaging time ozone metric in future studies will aid in interpreting the results in setting future ozone standards that use this metric.

An enlarging body of toxicological data from human and laboratory animal studies provides a basis for hypothesizing how ozone may cause biological changes with relatively high, short-term exposures in excess of the current NAAQS. Quantitative models do not exist for extrapolation of these short-term observations to lower ozone concentrations typical of ambient levels currently observed across the U.S. Lifetime studies with rats and mice exposed 6h/day, 5 days/ week to 0, 0.12, 0.5, or 1.0 ppm ozone revealed no difference in life span and only modest effects on body weight associated with ozone exposure. The ozone exposure had little or no measurable effect on pulmonary function. Histopathological changes were observed in the nasal and lung tissues of both rats and mice at the two highest ozone exposure levels. There were no ozone-related increases in the incidence of neoplasms in either species. Species differences in the disposition of inhaled ozone and in responses to inhaled toxicants require caution in quantitative extrapolation of these findings to humans.

During the Workshop discussions, major questions were raised concerning the conduct and reporting of the risk assessment used by the EPA to inform policy judgments in proposing the ozone NAAQS. A principal concern was that the risk assessment failed to integrate the key uncertainties in estimating the health risks of current ambient ozone and levels estimated to occur with alternative standards. The National Research Council previously recommended to the EPA that it integrate key uncertainties in assessing health risks of air pollutants into a single probability distribution when reporting final summary health risk estimates. The calculated health risks, and estimated reductions in risk for alternative standards, are highly dependent on the numerous assumptions used. When risk estimates are known to be highly sensitive to selection of a particular parameter, such as the Policy Relevant Background, then alternative assumptions should be included in the analysis and a range of uncertainty presented. Consideration of alternative approaches to defining Policy Relevant Background will, of necessity, extend to revision and re-interpretation of the risk assessment for ozone.

Another issue in the most recent risk assessment was its focus on ozone concentration-response functions using 24-h ozone concentrations. Only a very few of the exposure-excess risk coefficients used in the risk assessment were based on 8-h ozone concentrations, the averaging time of the ozone NAAQS since 1997. Thus, the calculated excess risk ascribed to the ozone concentrations measured in 2002, 2003, and 2004 were of uncertain relevance in setting a NAAQS with an 8-h averaging time. This is the case because the relationship between ambient ozone concentration-response coefficients for the three ozone metrics (1-h maximum, 8-h maximum, and daily average) is variable over time for any given city and among cities.

Future risk assessment can also be improved with regard to the manner in which the health risk findings are communicated. The recent risk assessment did not communicate how much of the estimated excess health risks was due to exposures that were on days where the peak 8-h average was below the standard of 84 ppb set in 1997. Moreover, it did not communicate that only a small fraction of the risk reductions that EPA estimates would ensue from a tighter NAAQS is due to changes in the peak ozone concentrations that are the public health concern. Analyses reproducing EPA's risk estimates revealed that a substantial share of the estimated change in health effects when tightening the standard from 84 ppb to a NAAQS in the range of 64–74 ppb was due to EPA's assumption that ozone would change on low-concentration days (e.g., those with peaks of 60 ppb and lower) to yet lower levels that would be unlikely under alternative Policy Relevant Background assumptions.

It is widely known that the science on ozone in ambient air and its health effects is extraordinarily complex. In this paper, we have touched upon key scientific issues that are crucial to the policy judgments that must be made in setting the NAAQS for ozone. In the preceding sections, we have examined much of the science behind these issues in the hope that they will broaden and expand the public discussion around the science undergirding the NAAQS for ozone. We hope that our review will stimulate further discussion of these scientific issues, conduct of additional research, and conduct of new analyses that will provide an improved scientific basis for the policy judgments that will have to be made by future EPA Administrators in considering revision of the ozone standard.

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RESEARCH ARTICLE

Reassessing the relationship between ozone and short-term mortality in U.S. urban communities

Richard L. Smith[1], Baowei Xu[1], and Paul Switzer[2]

[1]*Statistics and Operations Research, University of North Carolina, Chapel Hill, North Carolina, USA, and* [2]*Department of Statistics, Stanford University, Stanford, California, USA*

Abstract

Time-series studies that use daily mortality and ambient ozone concentrations exhibit estimates of ozone effects that are variable across cities. We investigate this intercity variability, as well as the sensitivity of the ozone-mortality associations to modeling assumptions and choice of daily ozone metric, based on reanalysis of data from the National Morbidity, Mortality and Air Pollution Study (NMMAPS). Previous work from NMMAPS reported a statistically significant association between ambient 24-h ozone and short-term mortality when averaged across 98 U.S. cities. Separation of ozone health associations from effects due to weather and co-pollutants is central to their interpretation. We examined the sensitivity of city-specific ozone-mortality estimates to adjustments for confounders and effect modifiers, showing substantial sensitivity. We examined ozone-mortality associations in different concentration ranges, finding a larger incremental effect in higher ranges, but also larger uncertainty. Alternative ozone exposure metrics defined by maximum 8-h averages or 1-h maxima show different ozone-mortality associations that cannot be explained by simple scaling relationships. The emphasis in earlier studies based on NMMAPS has been on the reporting of "national" effects, together with prediction intervals that suggest that these national values are precisely estimated. Our view is that ozone-mortality associations, based on time-series epidemiologic analyses of daily data from multiple cities, reveal still-unexplained inconsistencies and show sensitivity to modeling choices and data selection that contribute to serious uncertainties when epidemiological results are used to discern the nature and magnitude of possible ozone-mortality relationships or are applied to risk assessment.

Keywords: *Confounding, Effect modifiers, Exposure-response relationship, Multi-city time series, NMMAPS, Ozone metric, Regional and spatial variability*

Introduction

The purpose of this paper is to reexamine the evidence of an association between ambient ozone and nonaccidental all-cause mortality, based in particular on a series of papers by Bell and co-authors that used the NMMAPS database. NMMAPS refers to the National Morbidity, Mortality and Air Pollution Study, in which daily data on mortality, meteorology, and various air pollutants were collected for approximately 100 U.S. cities. Bell et al. (2004) calculated estimates for the ozone-mortality coefficient in each city after adjusting for meteorology, seasons, long-term trends, and a day of week effect. The results were highly variable from city to city, showing both positive and negative associations, but after a second-stage analysis that combined the results for 95 cities, they claimed a strong overall positive association. Bell et al. (2006) extended this to allow for the possibility of a nonlinear exposure-response association, claiming in particular that the effects of ozone and mortality persist down to quite low levels of ozone. Bell et al. (2007) developed and reinforced the argument first made in Bell et al. (2004), that there is no significant confounding effect due to particulate matter. Bell and Dominici (2008) noted that there is substantial regional and spatial variation in the ozone-mortality coefficient, but claimed that a large part of this could be explained in terms of effects modifiers, in which variation of the ozone-mortality coefficient from city to city is correlated with socioeconomic or other environmental variables measured for each city. These papers have been highly influential: for instance, they were extensively cited in the documentation supporting the 2008 decision of the U.S. Environmental Protection Agency

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Address for correspondence: Richard L Smith, PhD, Statistics and Operations Research, University of North Carolina, Chapel Hill, NC 27599-3260, USA. E-mail: rls@email.unc.edu

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(EPA) to revise the ozone standard, and more recently in a National Research Council (NRC) report on the possible benefits of reducing ambient ozone (NRC 2008).

In this paper, we reexamine all of these issues with particular attention to the question of sensitivity to alternative analyses. We look extensively at alternative treatments of meteorology and co-pollutants, showing that there are confounding and effect modifier relationships that have been understated or overlooked in previous studies. We also look at the dependence among different ozone metrics—those based on a 24-h average, on the daily maximum 8-h average, and on the daily maximum 1-h value. Most of the work by Bell and coauthors used 24-h average ozone, but the current EPA standard uses the daily maximum 8-h average, which itself superseded an earlier standard based on the 1-h maximum. We argue that conversion between these metrics using standardized ratios is potentially misleading. We provide evidence of regional and spatial variability, and argue that explanations in terms of effect modifiers, as in Bell and Dominici (2008), are at best only part of the answer—however, we provide a new interpretation of the possible effect of air conditioning, noted by them as well as by Levy et al. (2005). We also look closely at the evidence for a nonlinear exposure-response association.

Data and statistical methods

The principal data source for our analysis is the NMMAPS database, available publicly at http://www.ihapss.jhsph.edu. We have used daily mortality counts for 1987–2000, excluding accidental deaths, and subdivided them into three age categories (<65, 65–74, 75 and over) for 98 cities. The 97 cities (excepting Honolulu) that are in the mainland United States are classified into seven regions (Industrial Midwest, North East, North West, Southern California, South East, South West, Upper Midwest) using a classification that has been used in numerous NMMAPS reports (see, e.g., Samet et al. 2000b, page 8). Other variables that are part of the dataset and have been used in the present study are daily temperature, dewpoint, particulate matter of aerodynamic diameter equal to or less than 10 microns (PM_{10}) or 2.5 microns ($PM_{2.5}$), and both hourly and daily values for ozone, in most cases with no detrending and using ordinary rather than trimmed means for combining results across monitors. These variables were used in computing ozone-mortality coefficients for each city under a variety of statistical models. Because, in many cities, ozone data are only available for summer months (April through October), we computed ozone-mortality coefficients that are restricted to those months, as well as those using all available data (henceforth called all-year estimates).

In addition to the above, our analysis considered numerous variables, defined at the city level, that are used later in the paper for an effects modifier study. These include 77 "city census" variables that are part of the NMMAPS database. Although some are duplicates and not all are suitable for use as demographic covariates, the majority are indicators of population distribution, housing, educational level, race, income, etc. In many cases we have standardized the census data to proportions rather than counts, for example, racial variables have been expressed as proportions of total population. The database includes indicators of the numbers of age 65+ residents (subdivided into owners and renters) who last moved during different time periods. These have been consolidated into the proportion of all age 65+ residents who have moved since 1995, and similar proportions for age 65+ owners and for age 65+ renters. We also included six "environment" variables, also constructed from the NMMAPS database: mean overall values for each city of ozone (summer only, to ensure comparability among means for different cities), PM_{10} and $PM_{2.5}$, sulfur dioxide (SO_2), daily mean temperature (average of daily maximum and daily minimum), and dewpoint.

We independently constructed a table of air conditioning use by city. Bell and Dominici (2008) noted that such data are included in two sources of the American Housing Survey (AHS 2006): a "metropolitan" survey, which is an extensive survey of selected metropolitan areas conducted every 4 or 6 years, and a "national" survey that comprises at least 55,000 houses every 2 years, that are widely scattered across the United States. However, the metropolitan survey covers only about half the NMMAPS cities, which in preliminary analyses proved inadequate to demonstrate a clear-cut association with the city-specific ozone-mortality coefficients. We therefore used national survey estimates from 1997, 1999, 2001, 2003, and 2005, collating reported air-conditioning use with location defined by standard metropolitan statistical area (SMSA). Two particular variables were compiled, one an indicator of central air condition and the other of window air conditioners. Bell and Dominici (2008) combined the two into "all AC," but also considered "central AC" as a separate variable; they did not consider "window AC" as we do here. Average AC use was computed across all available years for each NMMAPS city, weighted by the number of available survey results in each year. By this method we were able to compute air conditioning use statistics for 79 of the 98 NMMAPS cities. It should be noted that the time period covered by the AC surveys is not the same as that of the NMMAPS data, but the interyear correlations were high (.96 to .99 for central AC; .82 to .93 for window AC) so it seems likely that AC use during 1997–2005 is also a good proxy for AC use during the earlier time period of the NMMAPS mortality data.

This paper uses a wide variety of statistical methods. Most analyses used the R statistical package (R Development Core Team 2007). The initial analysis follows the method described by Bell et al. (2004). It is a two-stage analysis where the first stage is a Poisson regression allowing for overdispersion, with mortality (subdivided into three age groups) as the response variable. We allowed for meteorology by defining covariates, temperature and dewpoint on the current day (lag 0), plus two additional variables representing averages of temperature and dewpoint over lags 1–3, each adjusted for the current day's temperature and dewpoint (these values are included in the NMMAPS database based on a calculation originally described by Curriero et al. [2002]). For reference in future discussion, we call this the NMMAPS meteorology model. The meteorological variables were modeled nonlinearly using natural splines, typically with 6 degrees of freedom for temperature and 3 degrees of freedom for dewpoint, the same as Bell et al. (2004). Long-term trends were also modeled nonlinearly, through natural splines with 7 degrees of freedom per year, and an interaction for the three age groups where we used the public R code cited by Bell et al. (2004). Day of week was also included as a covariate. Finally we included ozone initially through 24-h averages, but with various combinations of lags. Ozone may be represented as a single day's value at lag 0, 1, or 2, or as the average of lags 0 and 1 (we call this the 0-1 model), or through the "constrained distributed lag" model of Bell et al. (2004). In the latter, ozone is represented through the value at lag 0, the average of lags 1, 2, and the average of lags 3, 4, 5, 6, each with its own regression coefficient, and the sum of the three coefficients taken as the "ozone effect." In practice, this is rewritten so that one coefficient represents the overall effect and the other two as contrasts, allowing us to estimate a single "ozone-mortality coefficient" and its standard error for each city. An alternative is the "unconstrained distributed lag" model in which each of lags 0 through 6 gets a separate regression coefficient; Bell et al. (2004) prefer the constrained version but we have found that there is very little difference between the constrained and unconstrained distributed lag models. We have also considered analyses based on 8-h or 1-h ozone, where the raw data are hourly values from NMMAPS, and we have defined 8-h ozone as the maximum of the average of 8 consecutive hourly values in any 24-h period, and 1-h ozone as the largest of the hourly values on a given day. In computing 8-h ozone, we have followed the 75% rule (also used by EPA): 75% of the hourly values in any 8-h period are needed for the 8-h average to be counted, and 75% of the 8-h averages within a 24-h period are needed for the daily maximum 8-h average to be counted. All days not meeting these criteria are flagged as missing values. In analyses that also include PM_{10} or SO_2, we have used the 24-h average at lag 1, because in earlier NMMAPS analyses (Dominici et al. 2003) this was found to be the most significant lag for both PM_{10} and SO_2.

We considered two alternatives to the NMMAPS meteorology model. One is a simple replacement of the adjusted lagged temperature and dewpoint variables by the unadjusted 3-day means of temperature and dewpoint over lags 1–3. The second is what we call the "extended" meteorology model. This is a distributed lag model for meteorology, using separate temperature and dewpoint values for each of lags 0 through 6, each modeled nonlinearly through natural splines of respectively 4 and 3 degrees of freedom. The rationale behind this model is that, if the ozone effect is to be represented by a distributed lag model, then for comparability purposes, meteorology should be represented in a similar way.

These variables were included in an overdispersed Poisson regression model, also known as a generalized linear model (GLM), and fitted using the "glm" function in R. The result of these analyses was an estimate, together with its standard error, of the ozone-mortality coefficient in each city, expressed in percent rise in mortality per 10 ppb rise in ozone.

The second phase of the statistical analysis is based on the random effects model:

$$\theta_c \sim N[\mu, \tau^2], \tag{1}$$

$$t_c \mid \theta_c \sim N[\theta_c, s_c^2] \tag{2}$$

where θ_c is the true coefficient in city c, t_c is the estimate from stage 1, s_c is the standard error from stage 1, and N denotes normal distributions (approximate in the case of (2), because the distribution of a GLM estimate is known to be approximately normal). Equations (1) and (2) describe a two-level normal model where the objective is to estimate the hyperparameters μ and τ^2 to obtain posterior distributions for the θ_c. A convenient method for doing this is the Bayesian algorithm *tlnise* that was developed by Everson and Morris (2000) and is available as a downloadable package for R, written by Dr. Roger Peng from the earlier S-Plus code of Everson. However, we have also used a restricted maximum likelihood (REML) approach that is described in Appendix 1 and produces very similar results.

For reasons described in more detail later, we do not accept that μ is the most appropriate parameter to define a "national mean." An alternative approach is to take the weighted average of the city-based estimates across all cities, using weights proportional to the population in each city. That is natural, because risk assessments in effect try to estimate the total population at risk, so the contribution to the total risk from a given city should be proportional to the population of that city. Mathematically, we formulate this as predicting $\Sigma w_c \theta_c$ where the weight w_c is proportional to the population of city c. The optimal predictor when τ^2 is known is $\Sigma(w_c t_c \tau^2/(s_c^2 + \tau^2)) + M\Sigma(w_c s_c^2/(s_c^2 + \tau^2))$, where $M = [\Sigma t_c/(s_c^2+\tau^2)]/[\Sigma 1/(s_c^2+\tau^2)]$ is the weighted least squares estimator of μ, and the corresponding mean squared prediction error $\Sigma(w_c^2 s_c^2 \tau^2/(s_c^2 + \tau^2)) + (\Sigma w_c s_c^2/(s_c^2 + \tau^2))^2/\Sigma(s_c^2 + \tau^2)$. In the case where τ^2 is unknown, we use the output from *tlnise* to develop a Monte Carlo sample from the posterior distribution. These formulas are applied to each member of the Monte Carlo sample to derive the mean and variance of the posterior distribution. An outline derivation of these formulas is given in Appendix 2.

A major sensitivity issue is whether any other air pollutant could be confounding the ozone effect. Bell et al. (2004) claimed that for the NMMAPS dataset, PM_{10} is not a significant confounder for ozone. Bell et al. (2007) extended that claim to cover also daily $PM_{2.5}$, and gave several other analyses. To the best of our knowledge, this question has not been examined with respect to other possible co-pollutants, though Franklin and Schwartz (2008) showed a 35% reduction in the ozone-mortality coefficient when sulfate particles were included in the model, based on a different and substantially smaller dataset.

There are several difficulties in making this comparison for the NMMAPS dataset. Ideally we would prefer to use $PM_{2.5}$ (fine particulates), as this is the variable used for the main EPA standard for particulate matter. However, as pointed out by Bell et al. (2007), within the NMMAPS dataset, data for are $PM_{2.5}$ very limited. For the present study, we use PM_{10} on grounds of data availability, though bearing in mind that an observed association with PM_{10} may in fact be due to $PM_{2.5}$ or any other component of PM_{10}, such as sulfate particles. Even then, there is a difficulty, because in most cities, PM_{10} has been measured only once every 6 days, as required by EPA regulations that were in force at the time the data were collected. Therefore, the only realistic analysis is to repeat the foregoing ozone-only analysis, but restricted to days on which PM_{10} is also available, and then to run the same analysis with both ozone and PM_{10} as pollutants. Note that this methodology does not permit a distributed lag model for PM_{10}, because such a model requires daily data, so we have taken PM_{10} at lag 1, which has been found in previous studies (e.g., Dominici et al. 2003) to be the single-day lag of PM_{10} that has the strongest association with mortality. The data deficiency also has an implication for the effects themselves, that it is much harder to detect statistically significant associations based on such a reduced dataset.

Apart from the possibility that meteorology or co-pollutants may act as confounders, there is the somewhat different question of whether they may be effect modifiers. For example, is the effect of ozone on mortality at high temperatures the same as at low temperatures? In this context, we are considering *within-city* effect modifiers, where we examine the influence of the potential effect modifier first within each city, only then combining the city estimates into an overall population-weighted average. This is different from using *between-city* effect modifiers to explain the variation in ozone-mortality coefficients from city to city, as was done in Bell and Dominici (2008) and is discussed further below.

For temperature, the analysis is as follows. The "constrained distributed lag" model actually contains three ozone variables, the mean over lags 0–6 and two other variables representing differences in means over subsets of lags 0–6. If these three variables are written x_1, x_2, x_3, then we replace them by six variables, x_1w, $x_1(1-w)$, x_2w, $x_2(1-w)$, x_3w, $x_3(1-w)$, where w is an indicator variable, 1 if the current day's temperature is greater than the median temperature for that city, 0 otherwise. We also include w itself as a covariate in the regression. Note that the median temperature is different for each city, and in cases where summer-only data are used, the median is also computed for summer-only data. The regression coefficients associated with the first two variables, x_1w and $x_1(1-w)$, represent the overall ozone-mortality effects above and below the temperature median. These coefficients are then combined across cities using a population-weighted average. Similar analyses have been performed for two other potential effect modifiers, PM_{10} and SO_2. We considered SO_2 because Franklin and Schwartz (2008) showed that sulfate particles may be a confounder of the ozone effect. Sulfate particles do not form part of the NMMAPS dataset, but it is possible that gaseous SO_2 may be a proxy for sulfate particles, or that SO_2 may independently have an effect on mortality. Simultaneous measurements of ozone and SO_2 are available in 81 of the 98 NMMAPS cities, so the analysis is confined to those cities.

In some of our analyses, we also use a more general version of the random effects model, replacing Equation (1) by

$$\theta_c \sim N[x_c^{T}\beta, \tau^2], \qquad (3)$$

in which x_c denotes a vector of covariates in city c and β is some vector of regression coefficients (Equation (2) remains the same). This can also be fitted using *tlnise*. The main application we have made of this is for regional analyses, in which x_c represents an indicator vector for region (e.g., if city c lies in the jth region out of m regions, x_c is a vector of dimension m consisting of 1 in the jth component and 0 in all other components) and the components of β are means for each region. When combined with a uniform prior on β we call this the "regional prior" model, to distinguish it from the "national prior" in Equation (1).

A more general model still replaces the regression function $x_c^{T}\beta$ by a smooth function of latitude and longitude. In the present paper, this has been implemented by treating the smooth function as a sample from a continuous-parameter Gaussian stochastic process; the resulting estimation/interpolation algorithm is similar to the geostatistics procedure known as kriging.

Appendix 3 contains mathematical details of this method.

For between-city effect modifier analyses, we could again proceed with a Bayesian analysis based on (3), where the covariates x_c include the effect modifier. For the results presented here, we have used a non-Bayesian analysis treating each city coefficient as a random effect whose mean is a linear function of the effect modifier and whose variance is τ^2, estimated by REML using the method described in Appendix 1. This method is equivalent to the mixed effects meta-regression described by Bell and Dominici (2008). One advantage of the REML approach in this context is that it is very easy and quick to develop a test for statistical significance of the effect modifier, based on the estimated regression coefficient and its standard error; whereas the corresponding Bayesian test, although well defined, requires integrating over a Monte Carlo sample and is therefore less convenient to implement.

Results

The first step was to reproduce the main result of Bell et al. (2004), which used 24-h ozone in a "constrained distributed lag" model, with adjustments for daily mean temperature and dewpoint, lagged values of temperature and dewpoint

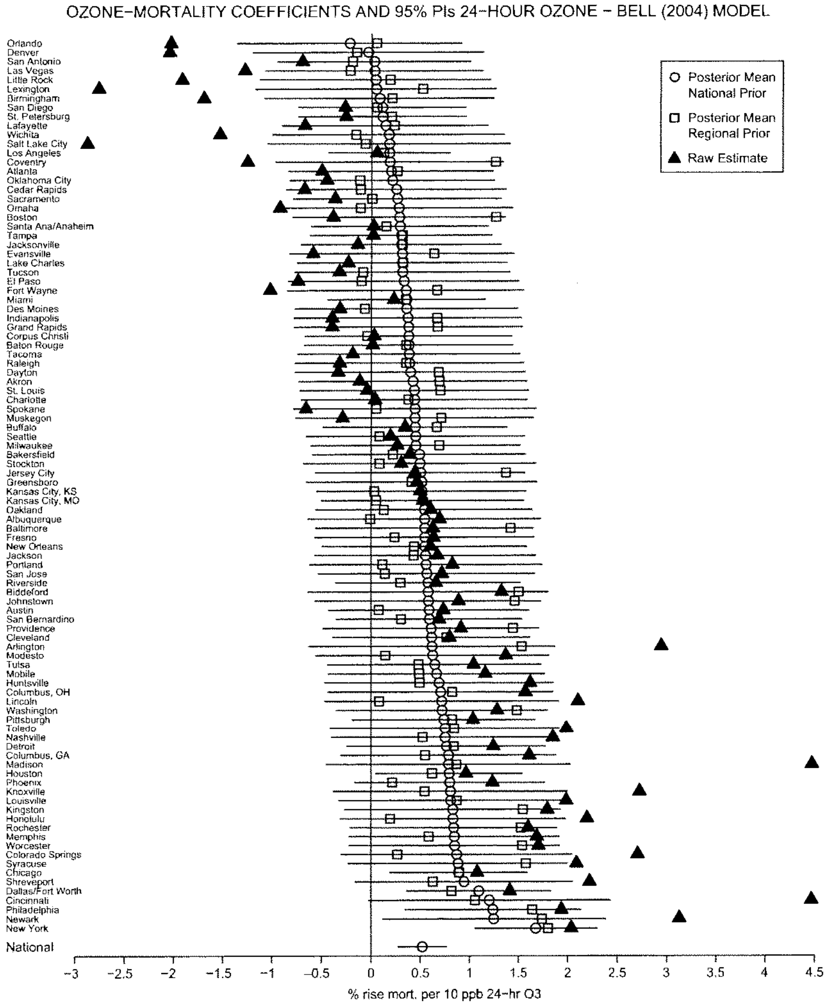


Figure 1. Ninety-five percent posterior intervals for the ozone-mortality coefficients, all-year data, by the hierarchical Bayesian method as in Figure 2 of Bell et al. (2004). The Bayesian posterior estimates under the "national prior" (circles) are shown alongside those for the "regional prior" (squares) and the raw maximum likelihood estimates (triangles).

(days 1-3) adjusted for current day, plus long-term trends and a day of week effect. The second stage of the analysis used a Bayesian hierarchical model based on (1) and (2) ("national prior," same as Bell's analysis). Because the R code to perform the individual city analyses is available on the NMMAPS Web site, we followed that code to reproduce the Bell result exactly in this case. The resulting posterior estimates and 95% prediction intervals are shown in Figure 1, which corresponds to Figure 2 of Bell et al. (2004). The units of all estimates are percent change in mortality associated with a 10 ppb rise in ozone. Also plotted on Figure 1 are the raw maximum likelihood estimates and the posterior means under an alternative "regional prior" based on Equation (3). The raw estimates are shown to make the point that there is already a great deal of reduction in variance in passing from the raw to the posterior estimates, even before computing the national average estimate (μ and its 95% prediction interval) at the bottom of the plot. The estimates are, however, sensitive to the prior distribution, as is clear from the fact that for many cities the posterior mean under the regional prior is near one of the endpoints of the 95% prediction interval computed under the national prior.

The posterior mean of μ (in this instance, 0.52, with a posterior standard deviation of 0.12) has generally been interpreted as a national estimate of the ozone-mortality coefficient, and in many publications, this has been quoted as if it were a truly representative effect. However, it is far from clear what it represents. In this case the population-weighted mean of the raw estimates is 0.62, different from the posterior mean of μ. We could also consider the mean of raw estimates weighted by reciprocal of squared standard error (the classical statistical rule for combining estimates), which in this instance is 0.61, but this also does not correspond to μ. The last two estimates should in most cases be very similar, because the variance of the parameter estimate should be proportional to the reciprocal of population. However, the estimated μ is closer to the unweighted mean of the raw estimates, which is 0.50.

The Bayesian analysis of the population-weighted mean leads to a posterior mean of 0.62, with a posterior standard deviation of 0.10. Further detailed results, for this and a number of other analyses to be described later, are in Table 1.

Confounding and effect modification

Next, we consider the sensitivity of these estimates to alternative treatments of meteorology, or to co-pollutants. The "extended meteorology" models in Table 1often lead to lower estimates of the overall ozone-mortality coefficient, especially for all-year estimates, which suggests that they are more efficient at dealing with the confounding effect of temperature. In most cases, the difference in the national or population-weighted average point estimates is less than 10%, which is not of very great practical significance. Later in the paper, we include the extended meteorology model in some of the individual-city comparisons, to make a more specific comparison between the two.

For the national-average effect (μ), we find a posterior mean ozone-mortality coefficient of 0.40 (posterior standard deviation 0.23) when fitted to days on which lag-1 PM_{10} is available but not included in the model, and posterior mean 0.31 (0.23) when the same analysis is repeated including PM_{10} as a co-pollutant. Similar results for the population-weighted average and for summer-only data are included in Table 1, using both the NMMAPS and extended meteorology models. It is difficult to evaluate the statistical significance of these results in view of the large posterior standard deviations (a consequence of the 6-day sampling), but in most cases, the ozone-mortality coefficient is reduced by between 22% and 33% as a result of including PM_{10} as a co-pollutant.

Further evidence of this PM_{10} confounding effect is in Figure 2. The top plot here shows the raw estimates for the ozone-mortality coefficient computed with PM_{10}, plotted against those without PM_{10}. There is no visual evidence of any effect due to PM_{10}, though in fact 56 of the 93 estimates (60%) are below the diagonal straight line. This plot shows the same estimates as Figure 3 of Bell et al. (2004). However, the bottom plot shows the same comparison made with the Bayesian posterior estimates. In this case, it is clear that nearly all (89 out of 93) the individual-city coefficients are smaller for the model with PM_{10} than the model without PM_{10}. The most likely explanation why the proportion increases so dramatically is that both sets of posterior estimates (with and without PM) are based on "shrinking towards the mean" (i.e., μ in the notation of Equation (1)) but the mean itself is lower in the with-PM analysis (.314) than in the without-PM analysis (.400). The emphasis that Bell et al. (2004) and other authors have given to using the Bayesian hierarchical model to reduce the variability of coefficients would suggest that the bottom plot is more meaningful and appropriate.

We next discuss results for the "within-city effect modifier" analyses; see Table 2, where we have also included results for 8-h and 1-h ozone, as considered later in the paper. For all three ozone metrics, temperature is not an effect modifier in the all-year analyses, but for the summer analyses, it is. In other words, during the summer months, the mortality effect of ozone is statistically significant only when temperature is above the median. We find that SO_2 is a statistically significant effect modifier in the all-year data based on 24-h ozone (the ozone-mortality effect higher at high SO_2), but not for summer-only data. Moreover, the statistical significance of the all-year result does not extend to the 8-h and 1-h ozone metrics. Overall, the evidence that SO_2 is an effect modifier does not seem strong. We also looked for evidence that SO_2 is a confounding variable, but concluded that it was not.

The result for PM_{10} is perhaps the most surprising, given the data sparseness issue already discussed, and the inconclusive results over whether PM_{10} is a confounder. For all three ozone metrics and both all-year and summer-only data, the ozone-mortality effect is statistically significant only when PM_{10} is above the median. In other words, although there is ambiguous evidence whether PM_{10} is a confounder, it clearly is an effect modifier.

Table 1. Summary of main hierarchical model results.

				Original tlnise				Pop.-weighted Average			
Ozone	Lags	Met	PM_{10}	All-yr	RMSE	Summ	RMSE	All-yr	RMSE	Summ	RMSE
24-hr	CDL	NMMAPS	No	0.522	0.124	0.404	0.133	0.618	0.096	0.459	0.107
24-hr	CDL	Ext	No	0.478	0.129	0.406	0.143	0.568	0.105	0.472	0.117
24-hr	CDL	NMMAPS	Part	0.400	0.231	0.367	0.257	0.479	0.192	0.400	0.216
24-hr	CDL	NMMAPS	Yes	0.314	0.230	0.265	0.261	0.360	0.193	0.267	0.223
24-hr	CDL	Ext	Part	0.379	0.248	0.376	0.281	0.434	0.212	0.410	0.240
24-hr	CDL	Ext	Yes	0.279	0.253	0.268	0.293	0.310	0.215	0.275	0.249
8-hr	CDL	NMMAPS	No	0.411	0.080	0.323	0.084	0.466	0.063	0.361	0.069
8-hr	CDL	Ext	No	0.402	0.082	0.366	0.091	0.438	0.069	0.405	0.076
8-hr	CDL	NMMAPS	Part	0.383	0.150	0.325	0.162	0.416	0.125	0.353	0.138
8-hr	CDL	NMMAPS	Yes	0.292	0.153	0.258	0.168	0.314	0.129	0.208	0.145
8-hr	CDL	Ext	Part	0.311	0.165	0.313	0.180	0.337	0.140	0.342	0.154
8-hr	CDL	Ext	Yes	0.212	0.171	0.244	0.190	0.227	0.144	0.269	0.163
1-hr	CDL	NMMAPS	No	0.292	0.054	0.239	0.057	0.299	0.043	0.250	0.047
1-hr	CDL	Ext	No	0.260	0.051	0.236	0.059	0.266	0.045	0.249	0.050
1-hr	CDL	NMMAPS	Part	0.296	0.098	0.259	0.108	0.299	0.083	0.266	0.092
1-hr	CDL	NMMAPS	Yes	0.213	0.102	0.200	0.112	0.213	0.086	0.206	0.097
1-hr	CDL	Ext	Part	0.257	0.105	0.244	0.116	0.261	0.091	0.250	0.100
1-hr	CDL	Ext	Yes	0.170	0.112	0.183	0.125	0.172	0.095	0.192	0.107
8-hr	0-1	NMMAPS	No	0.234	0.053	0.242	0.057	0.260	0.041	0.265	0.045
8-hr	0-1	Ext	No	0.244	0.050	0.250	0.054	0.256	0.043	0.261	0.047
8-hr	0-1	NMMAPS	Part	0.266	0.092	0.268	0.101	0.270	0.080	0.275	0.089
8-hr	0-1	NMMAPS	Yes	0.196	0.098	0.190	0.111	0.191	0.084	0.190	0.096

Note. First four columns indicate ozone metric (24-h, 8-h, 1-h); lag structure (CDL = constrained distributed lag model; 0-1 = average of lags 0 and 1); meteorology (NMMAPS or extended) and whether PM_{10} was included ("No" means PM_{10} not included; "Part" means analysis with ozone only but only calculated for days where PM_{10} was also available; "Yes" means PM_{10} was included as a co-pollutant. For each combinarion of ozone, meteorology and PM_{10}, we tabulate the all-year TLNISE estimate (μ) and its root mean squared error (RMSE); the summer TLNISE estimate and its RMSE; the all-year population-weighted average estimate and its RMSE; and the summer population-weighted average estimate and its RMSE. All estimates in units of percentage rise in mortality per 10 ppb rise in the relevant metric of ozone.

Ozone metrics

We examined whether results calculated using 24-h averaged ozone remain essentially unchanged when repeated using either the daily maximum 8-h average or the daily maximum 1-h value.

Figure 3 (top plot) shows posterior mean estimates by city, under the national prior, plotted against each other based on the 24-h and 8-h ozone metrics. The bottom plot shows the same thing comparing the 1-h and 8-h metrics. Corresponding plots were drawn for the raw estimates but are not shown here because the overall appearance was similar. These calculations show a correlation of the order of 0.7–0.8 between city-specific estimates under the different metrics, regardless of whether raw or posterior mean estimates are used. This is a moderately high correlation, but it also shows that the correspondence between the different metrics is by no means perfect. Summary results for 8-h and 1-h ozone are included in Table 1, based on percent rise in mortality per 10 ppb rise in ozone in the corresponding ozone metric.

The question naturally arises of how to express ozone-mortality results for the different metrics on a common scale so that they are directly comparable. Bell et al. (2004) provided results for the percent rise in mortality per 15 ppb rise in 8-h ozone or per 20 ppb rise in 1-h ozone (compared with 10 ppb for 24-h ozone), implying without stating directly that this made the estimates roughly comparable.

This is not an easy question to resolve. One possible solution is to rescale the ozone-mortality coefficients proportionally to the overall mean ozone level in the respective metrics. This would imply, for example, that we multiply the 24-h ozone-mortality coefficient by 0.646 to convert it to a scale comparable to the 8-h ozone-mortality coefficient. Here, 0.646 is the ratio, aggregated over all NMMAPS cities, of the mean level of 24-h ozone to the mean level of 8-h ozone. By comparison, Bell et al. used an implied ratio of 0.667 (= 10/15). However, the value of 0.646 is by no means constant over cities: individual-city estimates of the same ratio vary from 0.515 to 0.801. The issue is similar for the comparison between 1-h and 8-h ozone estimates: the overall averages of 1-h and 8-h ozone lead to a factor of 1.31 for converting 1-h ozone-mortality coefficient to corresponding 8-h values. However, the ratio for individual cities varies from 1.08 to 2.05. Bell et al. used an implied ratio of 1.33 (= 20/15). Ratios for summer-only ozone are almost the same (0.640 and 1.30 respectively to convert 24-h and 1-h ozone-mortality coefficients to their 8-h equivalents).

Using the factors 0.646, 1, 1.31 to convert results for all three ozone metrics into an equivalent based on 8-h ozone, the 24-h, 8-h, and 1-h results for all-year data translate into posterior means of 0.40 (standard deviation 0.06), 0.47 (0.06), and 0.39 (0.06). The corresponding results for summer only are 0.30 (0.07), 0.36 (0.07), and 0.33 (0.06). These results support the notion that of the three metrics, 8-h ozone leads to

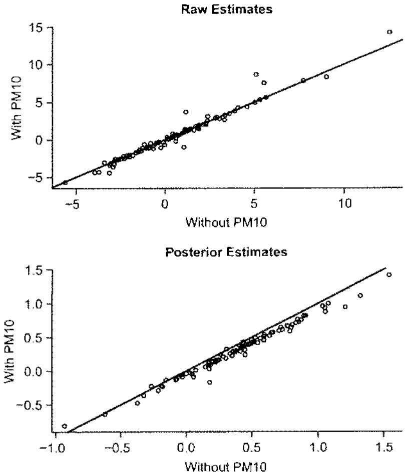


Figure 2. Plot of estimates including PM_{10} against those without. Top plot: based on raw estimates (this is the same as Figure 3 of Bell 2004). Bottom plot: based on posterior estimates. The posterior estimates are nearly all below the diagonal straight line, indicating that the PM-adjusted ozone coefficient is closer to 0 than the unadjusted ozone coefficient.

the strongest association with mortality, but subject to the heavy caveat that they are based on conversion factors that are highly variable over cities.

Figures 4 and 5 respectively show the individual-city estimates (raw estimates, posterior means under the national prior, and posterior means nnder the regional prior) for the associations of 8-h and 1-h ozone with mortality. Also shown are 95% prediction intervals under the national prior. Comparing these with Figure 1, there is in fact greater homogeneity in the national-prior posterior means than is the case for 24-h ozone. This might be considered another argument for using 8-h or 1-h ozone in preference to 24-h ozone. However, plotting the raw and regional-prior estimates on the same graph also highlights that the raw estimates are still much more variable than the posterior estimates, and that the regional-prior posterior means are in many cases substantially different from those based on the national prior. Thus, the broad issues about sensitivity of the ozone-mortality associations to alternative specifications of the statistical model are not resolved by switching to 8-h or 1-h ozone.

The analyses of co-pollutants as confounders or within-city effect modifiers were also repeated under 8-h or 1-h ozone, with results given in Tables 1 and 2 (no conversion factors were used in computing those tables).

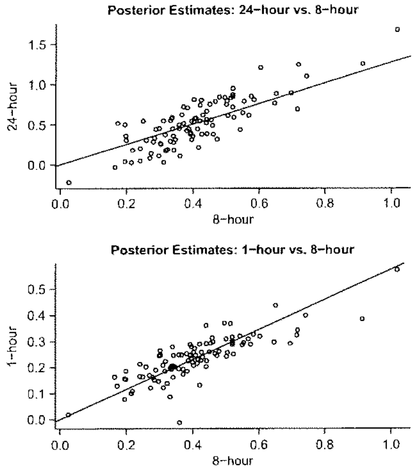


Figure 3. Scatterplots of posterior estimates corresponding to 24-h, 8-h, and 1-h ozone.

Regional and spatial variability

Earlier studies of the PM_{10}-mortality effect based on the NMMAPS data, such as those of Dominici et al. (2002, 2003), emphasized the variability of the effect across regions, which might be interpretable as due to different constituents of particulate matter. In the case of ozone, as far as we know, the possibility of a regional effect was not discussed anywhere before the paper of Bell and Dominici (2008). However, there is in fact a very strong regional effect, as seen in Table 3, where we present posterior means and standard deviations for μ and the population-weighted averages for the seven regions of the continental United States, using all three ozone metrics, for both all-year and summer data. Table 2 of Bell and Dominici (2008) shows a similar effect based on posterior means of the hyperparameters, using only 24-h ozone and all-year data. For 24-h ozone, the table shows a very clear statistically significant effect in the Industrial Midwest and (especially) North East regions, and a smaller effect from the South East (which appears to be primarily due to the results of Houston and Dallas/Fort Worth, which are part of the South East in this classification). The remaining regions do not show a statistically significant effect. The patterns based on 8-h and 1-h ozone are broadly similar.

A natural question is whether the differences among regions are statistically significant. For all six analyses (three ozone metrics, all-year and summer-only), we performed a likelihood-ratio test of the null hypothesis that the seven region means are the same, using a standard chi-square

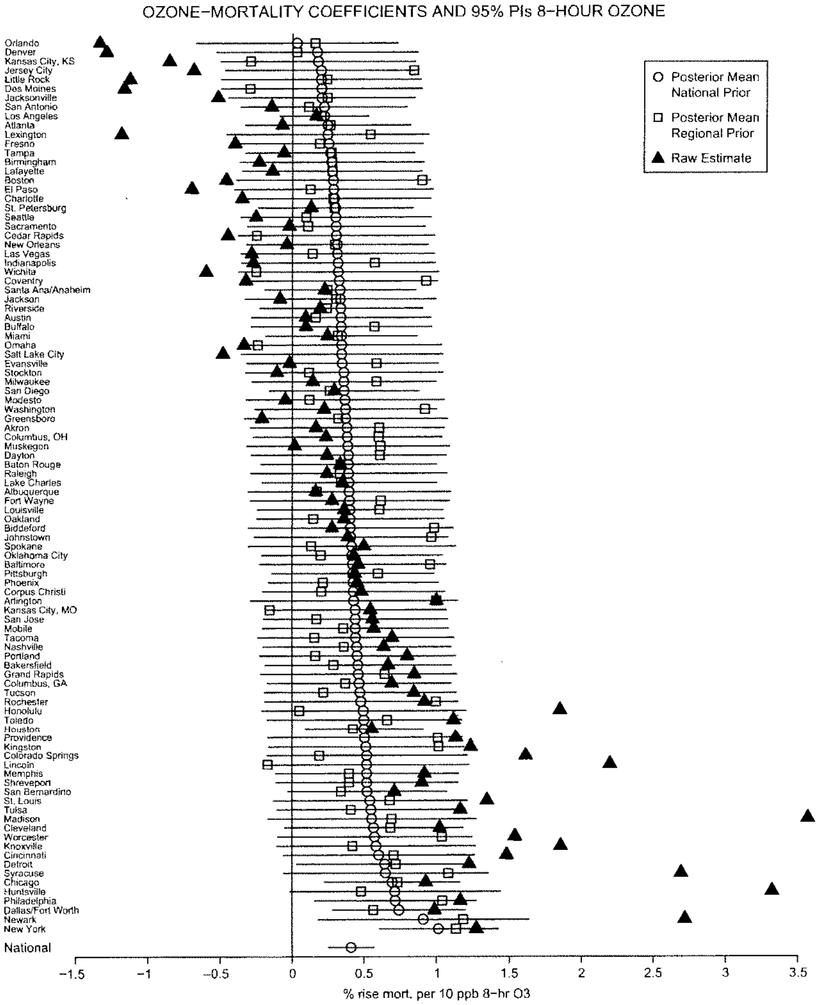


Figure 4. Ninety-five percent posterior intervals for the ozone-mortality coefficients, based on 8-h ozone, all-year data. The Bayesian posterior estimates under the "national prior" (circles) are shown alongside those for the "regional prior" (squares) and the raw maximum likelihood estimates (triangles).

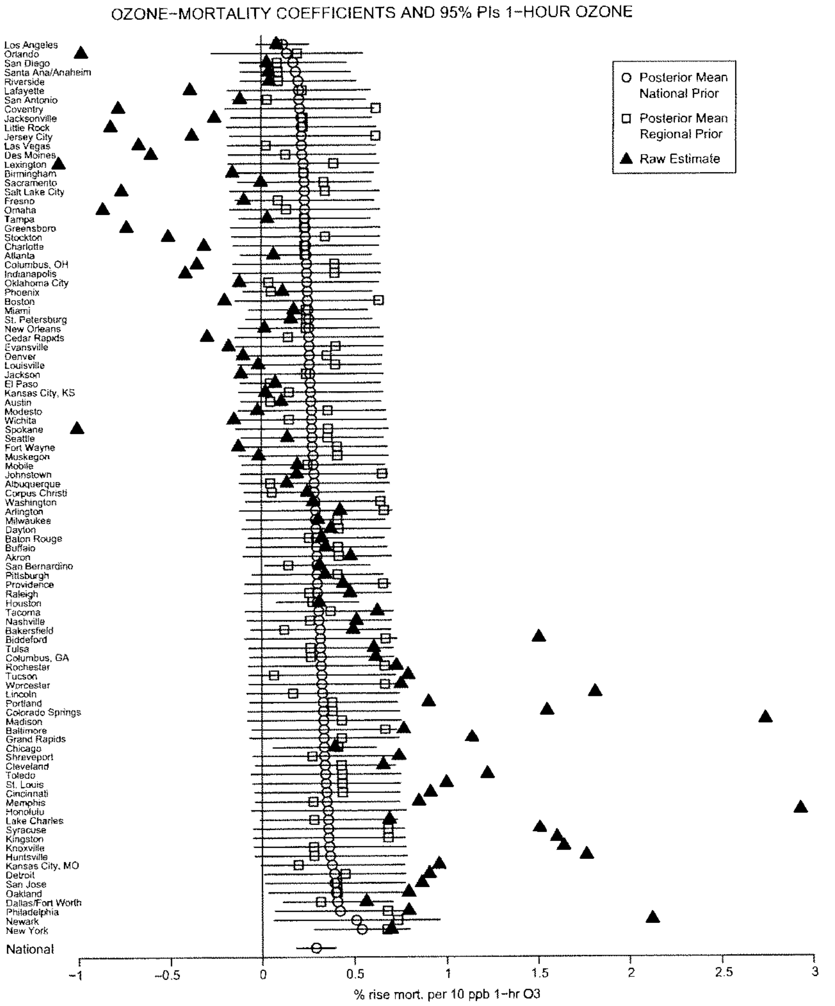


Figure 5. Ninety-five percent posterior intervals for the ozone-mortality coefficients, based on 1-h ozone, all-year data. The Bayesian posterior estimates under the "national prior" (circles) are shown alongside those for the "regional prior" (squares) and the raw maximum likelihood estimates (triangles).

Table 2. Within-city effect modifier results.

	TLNISE				Pop.-weighted Average			
Description	All-yr	RMSE	Summ	RMSE	All-yr	RMSE	Summ	RMSE
24-hour ozone, below temp. median	0.449	0.162	0.02	0.163	0.531	0.136	-0.019	0.144
24-hour ozone, above temp. median	0.582	0.138	0.581	0.162	0.655	0.106	0.699	0.126
8-hour ozone, below temp. median	0.478	0.120	0.151	0.109	0.509	0.099	0.138	0.099
8-hour ozone, above temp. median	0.378	0.090	0.357	0.105	0.435	0.069	0.433	0.080
1-hour ozone, below temp. median	0.360	0.094	0.149	0.083	0.352	0.074	0.129	0.070
1-hour ozone, above temp. median	0.278	0.062	0.264	0.072	0.289	0.048	0.296	0.054
24-hour ozone, below SO2 median	0.509	0.154	0.353	0.177	0.605	0.119	0.392	0.141
24-hour ozone, above SO2 median	0.726	0.163	0.527	0.179	0.807	0.119	0.570	0.138
8-hoor ozone, below SO2 median	0.406	0.098	0.314	0.111	0.446	0.078	0.330	0.091
8-hour ozone, above SO2 median	0.493	0.103	0.391	0.115	0.543	0.076	0.436	0.088
1-hour ozone, below SO2 median	0.230	0.064	0.186	0.080	0.236	0.052	0.188	0.062
1-hour ozone, above SO2 median	0.323	0.071	0.273	0.074	0.326	0.053	0.282	0.059
24-hour ozone, below PM10 median	-0.020	0.293	−0.111	0.318	0.100	0.235	-0.072	0.273
24-hour ozone, above PM10 median	0.569	0.228	0.564	0.275	0.603	0.200	0.581	0.242
8-hour ozone, below PM10 median	0.070	0.206	−0.004	0.243	0.163	0.160	0.068	0.188
8-hour ozone, above PM10 median	0.271	0.139	0.382	0.205	0.234	0.117	0.367	0.173
1-hour ozone, below PM10 median	0.077	0.135	−0.018	0.165	0.112	0.109	0.021	0.128
1-hour ozone, above PM10 median	0.332	0.105	0.350	0.119	0.324	0.089	0.347	0.104

Note. For each of three ozone metrics (24-h, 8-h, 1-h) and each of three potential effect modifiers (temperature, SO_2, PM_{10}), we show the estimated ozone-mortality relationships in a model that allows for separate linear ozone effects when the potential effect modifier is below or above its median, within a single overall regression model that includes adjustments due to temperature, dewpoint, seasonal and day of week effects, and long-term trends. Tabulated are point estimates (posterior means) and root mean squared errors, for all-year and summer-only data, using both the traditional TLNISE model and the alternative population-weighted average.

Table 3. Regional estimates.

		TLNISE				Pop.-weighted Average			
Region	Ozone	All-yr	RMSE	Summ	RMSE	All-yr	RMSE	Somm	RMSE
Indostrial Midwest	24-hour	0.755	0.263	0.816	0.232	0.682	0.279	0.723	0.253
North East	24-hour	1.507	0.268	1.669	0.216	1.289	0.294	1.450	0.246
North West	24-hour	0.071	0.413	0.058	0.394	0.240	0.487	0.218	0.471
Southern California	24-hour	0.198	0.301	0.153	0.235	-0.339	0.325	-0.348	0.259
South East	24-hour	0.405	0.199	0.482	0.174	0.284	0.216	0.340	0.194
South West	24-hour	-0.051	0.356	0.002	0.333	-0.044	0.393	0.017	0.371
Upper Midwest	24-hour	-0.039	0.485	-0.036	0.463	0.088	0.556	0.100	0.538
Industrial Midwest	8-hour	0.630	0.173	0.666	0.158	0.522	0.181	0.541	0.169
North East	8-hour	1.001	0.183	1.075	0.151	0.881	0.199	0.973	0.167
North West	8-hour	0.126	0.276	0.120	0.266	0.224	0.309	0.214	0.301
Southern California	8-hour	0.249	0.177	0.232	0.132	0.017	0.191	0.024	0.148
South East	8-hour	0.335	0.126	0.373	0.112	0.242	0.135	0.267	0.122
South West	8-hour	0.170	0.249	0.176	0.240	-0.044	0.274	-0.045	0.267
Upper Midwest	8-hour	-0.238	0.361	-0.209	0.354	0.112	0.408	0.141	0.402
Industrial Midwest	1-hour	0.419	0.128	0.424	0.122	0.349	0.136	0.350	0.129
North East	1-hour	0.664	0.124	0.674	0.108	0.585	0.137	0.614	0.118
North West	1-hour	0.370	0.180	0.362	0.178	0.304	0.199	0.299	0.197
Southern California	1-hour	0.103	0.090	0.095	0.065	0.065	0.102	0.057	0.074
South East	1-hour	0.253	0.087	0.259	0.082	0.199	0.096	0.209	0.089
South West	1-hour	0.046	0.181	0.044	0.179	-0.026	0.204	-0.025	0.201
Upper Midwest	1-hour	0.155	0.287	0.166	0.285	0.261	0.328	0.283	0.326

Similar to Table 1, except that results are subdivided into each of seven regions of the United States. All results for controlled distributed lag model with NMMAPS meteorology and without PM_{10}.

approximation to the distribution of the test statistic. The null hypothesis was rejected in every case, with p values from 0.017 down to 0.0015.

We can extend this calculation to the construction of spatial maps of the ozone-mortality coefficient. The methodology, which is described in more detail in Appendix 3, is an extension of the hierarchical model represented by Equations (1) and (2) to allow for spatial autocorrelation among the city-specific random effects. The technique is similar to kriging, which is a well-known method for spatial interpolation (Cressie 1993; Stein 1999) but allowing for the standard errors of the estimated random effects from the initial GLM part of the analysis. It is necessary to choose a parametric form of spatial correlation function, for which the method was to fit several possible models by the method of restricted maximum likelihood estimation (REML), choosing the best model as the one that gave the largest restricted likelihood. By this approach, we selected the Gaussian correlation function, $\rho = \exp(-(D/R)^2)$, where D is the distance (in kilometers) between two locations and R is a spatial parameter known as the range. In this kind of analysis, it is typically rather difficult to pin down R precisely and this is reflected in the wide range of estimates over the six datasets, and their wide confidence intervals; see Table 4. Some variants on the analysis included adding a nugget parameter to the variance, and accounting for anisotropy by using a linear transformation of the coordinate space in defining D (in the literature on spatial statistics this is called geometric anisotropy). Neither of these variants resulted in statistically significant changes in the model.

Table 4. Range parameters for the Gaussian spatial covariance functions used in drawing the spatial maps, together with 95% confidence intervals.

Model	Estimated Range (km.)	95% Confidence Interval
24-hour ozone, all year	327	(114, 938)
24-hour ozone, summer	1394	(378, 5134)
8-hour ozone, all year	427	(103, 1769)
8-hour ozone, summer	1387	(450, 4270)
1-hour ozone, all year	1084	(323, 3633)
1-hour ozone, summer	1264	(376, 4250)

Estimates and standard errors were calculated on a logarithmic scale using the method of restricted maximum likelihood; confidence intervals were also calculated on a logarithmic scale and transformed back to the original scale for the results presented here.

Figure 6 shows maps constructed based on all three ozone metrics for all-year data, and for the 8-h metric using summer data. (The other two cases, 24-h and 1-h ozone and summer data, were also drawn but are not shown here, because they are similar to the maps shown.)

In drawing these maps, it was considered desirable to use a common color scale. To ensure comparability between different ozone metrics, the interpolated ozone-mortality coefficients for 24-h and 1-h ozone were converted to an equivalent scale to those for 8-h ozone, using the factors 0.646 and 1.31 derived previously. As noted earlier, we do not believe any single conversion factor is adequate to compare different metrics, but these seem the most suitable values for the present purpose.

These maps reinforce the existence of a strong spatial effect. In all four maps, the ozone-mortality coefficient is highest in the region around New York, with other high spots around Chicago, throughout the Industrial Midwest, and down to eastern Texas. Other parts of the country, such as California, Florida, etc., seem to have very low ozone-mortality coefficients.

The regional analysis was also calculated for the within-city effect modifier results. We noted earlier that temperature is a statistically significant effect modifier for the summer-only data. If this effect is examined regionally, we find that it is actually significant only in the North East and Industrial Midwest regions. For PM_{10}, also, there appears to be a

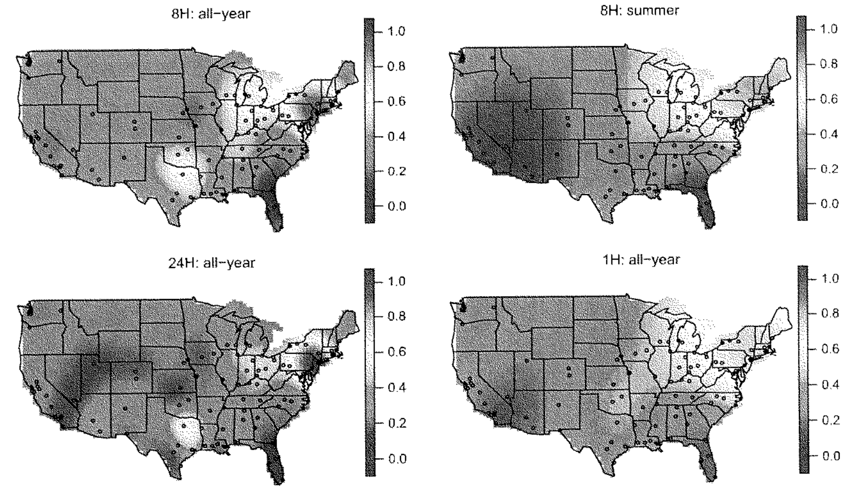


Figure 6. Map of spatially dependent ozone-mortality coefficient for 8-h ozone (all-year data), 8-h ozone (summer data), 24-h ozone (all-year data), and 1-h ozone (all-year data). (See colour version of this figure online at www.informahealthcare.com/iht).

regional effect, the evidence that PM_{10} is a significant effect modifier being strongest in the North East. In other calculations involving PM_{10} or SO_2 as an effect modifier, there did not appear to be a regional effect.

Between-city effect modifiers

Bell and Dominici (2008) sought to explain spatial variability among the ozone-mortality coefficients by constructing regression relationships involving numerous covariates defined at the city or community level. They called these covariates effect modifiers; we add the qualifier "between-city" to emphasize that this is a different analysis from the within-city effect modifiers considered earlier, though some of the variables are the same. In their study, they found that high unemployment, the proportion of Blacks or African Americans, use of public transportation, lower mean temperatures, and low usage of central air conditioning were all associated with a higher ozone-mortality coefficient. In a similar though not identical context, Krewski et al. (2000) referred to "ecological covariates" in describing factors that could influence citywide standardized mortality rates in a large prospective study using data from the American Cancer Society.

We have applied a similar analysis based on variables of a demographic or socio-economic nature, and various "environment" variables, as well as air-conditioning (AC) data. At the suggestion of a reviewer, latitude and longitude were also included as possible effect modifiers in this comparison. Results are summarized in Table 5. Of particular concern to us is the robustness of effect modifier analyses across different versions of the ozone-mortality relationship that correspond to the three ozone metrics and all-year and summer-only analyses. Therefore, we have ordered the candidate effect modifiers according to the largest (least significant) *p* value across all six analyses. The first 10 rows in Table 5 list all the variables that were significant at level 0.05 under all six analyses.

In processing the AC data, Bell and Dominici considered two measures: "central AC" and "any AC." Bell and Dominici found a statistically significant effect for central AC (*p* value 0.02) but not for any AC. We have preferred, instead, to treat the proportion of houses with window AC units as a separate variable. In fact, this turns out to be much more highly significant (and with a positive sign, i.e., increased use of window AC corresponds to an increased ozone-mortality coefficient). In all six analyses, the result for window AC is significant with a *p* value of <0.001.

Of the other variables that are statistically significant for all six ozone measures, four are related to changing residence: they show that communities where a high proportion of residents have moved since 1995 are associated with a lower ozone-mortality coefficient. The two variables "proportion drive to work" and "proportion public transport to work" are most likely complementary measures of air pollution exposure during commuting and this is reflected in the similar *p* values and opposite signs of the effects. We also note that latitude and longitude are statistically significant effect modifiers in most analyses, implying a geographic effect (the ozone-mortality coefficient increases as we move further north or east), though not as strongly significant as the variables related to AC, change of residence or transportation. Finally we see two "environmental" variables that are significant: mean temperature and the mean level of SO_2. It should be noted that other air pollution related citywide variables, such as the mean level of ozone, PM_{10} or $PM_{2.5}$, are not significant under this analysis.

Bell and Dominici (2008) gave particular attention to two variables, the proportion of blacks and the proportion unemployed, reporting that each was significant with *p* value about 0.03. For comparison purposes, these variables are also included in Table 5. Our result for 24-h ozone, all-year analysis confirms the statistical significance of these two variables, but other analyses do not corroborate this conclusion. Therefore, the relationship between the ozone-

Table 5. Summary results for between-city effect modifiers.

	24-hour	24-hour	8-hour	8-hour	1-hour	1-hour
Variable	AY	Summ	AY	Summ	AY	Summ
Window AC	3.5	3.2	2.1	2.1	1.1	1.1
SE	0.7	0.8	0.5	0.5	0.3	0.3
p- value	0.00001	0.0001	0.00002	0.00003	**0.0006**	0.0003
R^2	0.22	0.17	0.21	0.20	0.14	0.16
Proportion in different house in 1995	-5.9	-6.0	-3.7	-4.1	-2.7	-2.5
SE	1.7	1.9	1.1	1.2	0.8	0.8
p- value	0.0008	0.0018	0.0014	0.0004	0.0005	**0.0024**
R^2	0.11	0.10	0.10	0.11	0.12	0.09
Proportion 65+ moved since 1995	-7.0	-7.7	-4.0	-5.3	-3.2	-3.0
SE	2.0	2.3	1.4	1.5	0.9	1.0
p- value	0.0009	0.0009	**0.0047**	0.0004	0.0006	0.0028
R^2	0.11	0.11	0.08	0.12	0.12	0.09
Proportion public transport to work	3.5	3.0	1.8	1.8	1.0	1.1
SE	0.9	1.0	0.6	0.5	0.4	0.3
p- value	0.0001	0.0039	0.0017	0.0016	**0.0049**	0.0018
R^2	0.14	0.08	0.10	0.10	0.08	0.10

Table 5. continued on next page

	24-hour	24-hour	8-hour	8-hour	1-hour	1-hour
Variable	AY	Summ	AY	Summ	AY	Summ
Proportion renters 65+ moved since 1995	-4.5	-4.1	-2.3	-2.3	-1.4	-1.2
SE	1.1	1.2	0.7	0.7	0.4	0.4
p- value	0.00005	0.0008	0.0013	0.0010	0.0023	**0.0068**
R²	0.16	0.11	0.10	0.11	0.09	0.07
Mean S02	0.115	0.101	0.062	0.056	0.049	0.042
SE	0.032	0.035	0.021	0.021	0.011	0.012
p- value	0.0007	0.006	0.004	**0.010**	0.00004	0.001
R²	0.14	0.09	0.10	0.08	0.19	0.12
Proportion drive to work	-2.9	-2.4	-1.5	-1.4	-0.9	-0.8
SE	0.8	0.9	0.5	0.5	0.3	0.3
p- value	0.0002	0.006	0.002	0.005	0.006	**0.013**
R²	0.14	0.08	0.09	0.08	0.08	0.06
Latitude	0.046	0.061	0.035	0.045	0.028	0.031
SE	0.021	0.023	0.014	0.015	0.010	0.010
p- value	**0.033**	0.011	0.015	0.003	0.005	0.002
R²	0.05	0.07	0.06	0.09	0.08	0.09
Proportion owners 65+ moved since 1995	-5.5	-5.7	-2.8	-3.8	-2.4	-2.1
SE	1.9	2.1	1.3	1.4	0.8	0.9
p- value	0.005	0.008	**0.036**	0.006	0.005	0.022
R²	0.08	0.07	0.04	0.07	0.08	0.05
Mean temperature	-0.029	-0.038	-0.022	-0.028	-0.018	-0.019
SE	0.014	0.015	0.009	0.009	0.006	0.006
p- value	**0.037**	0.012	0.015	0.003	0.004	0.004
R²	0.04	0.06	0.06	0.09	0.09	0.08
Longitude	0.014	0.018	0.009	0.010	0.008	0.007
SE	0.007	0.008	0.005	0.005	0.002	0.002
p- value	0.043	0.025	**0.056**	0.039	0.001	0.006
R²	0.04	0.05	0.04	0.04	0.11	0.08
Central AC	-1.2	-1.1	-0.9	-0.8	-0.6	-0.4
SE	0.5	0.5	0.3	0.3	0.2	0.2
p- value	0.014	0.039	0.004	0.015	0.006	**0.080**
R²	0.08	0.05	0.11	0.07	0.09	0.04
Proportion black/African American	1.5	1.2	0.6	0.6	0.8	0.6
SE	0.8	0.8	0.5	0.5	0.3	0.4
p- value	0.04	0.15	0.20	**0.23**	0.02	0.12
R²	0.04	0.02	0.02	0.01	0.06	0.02
Proportion unemployed	12.8	4.8	5.0	3.4	3.1	2.6
SE	5.8	6.5	3.7	4.0	2.6	2.7
p- value	0.03	**0.46**	0.19	0.40	0.23	0.35
R²	0.05	0.01	0.02	0.01	0.01	0.01

Note. For each potential effect modifier, we show the regression coefficient (increase in mortality/ozone coefficient per 1-unit rise in effect modifier) together with standard error, *p* value, and R^2, in a random effects regression model fitted by the method of restricted maximum likelihood. The effect modifiers are ordered according to the largest *p* value (shown in bold) over the six analyses of each effect modifier.

mortality coefficient and these two ecological variables may well be spurious.

Nonlinear exposure-response relationships

The analyses so far have all been based on a linear relationship between the logarithm of the daily mortality rate and the level of ozone. However, nonlinear relationships are of interest for a variety of reasons. If there were a threshold below which there is no relationship between ozone and mortality, this would be of obvious relevance in setting a standard. Even in the absence of a threshold, if the slope of the relationship between log mortality rate and ozone were substantially different over different ranges of ozone, this could affect calculated estimates of the expected benefit associated with a reduction of ozone levels.

In this analysis, following Bell, we have used "0-1" ozone measure (average of daily ozone at lags 0 and 1), though using any of the 24-h, 8-h, and 1-h metrics for computing a daily ozone value. This is used in preference to a distributed lag model because it is not clear how to implement the latter in the case of a nonlinear ozone-mortality association.

Bell et al. (2006) looked at nonlinear effects in a variety of ways. One approach was the "subset approach": subset the data by restricting to days below a cutoff, and recompute the ozone-mortality coefficient. They repeated this calculation for several cutoffs down to 15 ppb, showing a statistically significant effect at all cutoffs from 30 ppb and higher. It should be pointed out that their analysis was still based on 24-h ozone data, which, as we have seen, do not translate directly to an equivalent level for 8-h ozone.

In Figure 3 of the same paper, Bell et al. also computed a smooth nonlinear exposure-response relationship using splines. Their analysis is complicated, requiring fitting a multiparameter spline function for each city, followed by a combination across cities. They do not provide full details of their methodology and we have not succeeded in reproducing their figure. However, below we propose an alternative "piecewise linear" approach which has a similar effect. Let us first consider the subset approach. As noted earlier in this paper, we prefer to combine data across cities using a population-weighted average rather than the posterior distribution of the parameter μ to represent a national average. Bell's calculation was repeated using this measure, producing the figure at the top of Figure 7. This is very similar to Bell's Figure 2, and supports Bell's conclusion that there is a statistically significant relationship for all cutoffs above 30 ppb. The result for 25 ppb shows that the 95% posterior predictive interval (PI) just covers 0, which we are interpreting here as not statistically significant, though it is very close to being so.

The subset analysis shows the effect of ozone at very low levels. However, for policy purposes it may be that ozone levels at a more moderate level, for example between 40 and 80 ppb, are more relevant to risk assessments. Therefore, to make a contrast with the subset approach, we also consider a "reversed subset" approach in which the analysis is restricted to ozone levels above a cutoff, rather than below. We have considered cutoffs in the range 15–60 ppb, showing very little change in the estimates within the range 15–40 ppb but then greatly increasing variability in the estimates as the cutoff gets higher (Figure 7, bottom).

The piecewise linear approach assumes that the contribution to log mortality rate due to an ozone level x is of the form

$$f(x) = \beta_1 x \text{ for } x \le 40,$$

$$40\beta_1 + \beta_2(x - 40) \text{ for } 40 \le x \le 60,$$

$$40\beta_1 + 20\beta_2 + \beta_3(x - 60) \text{ for } 60 \le x \le 80 \qquad (4)$$

In other words, the slopes are respectively β_1, β_2, and β_3 in the ranges 0–40, 40–60, and 60–80 ppb (in this approach, we do not consider ozone levels above 80 ppb). The choice of break points at 40, 60, and 80 ppb is to some extent arbitrary though these also seem natural choices, e.g., 40 ppb corresponds to the background ozone level assumed for EPA's 1997 ozone review and 80 ppb was until recently the ozone standard; 60 is chosen simply as midway between 40 and 80. All estimates based on (4) are for the 8-h ozone metric.

The model (4) is estimated first for each city by a direct extension of the method used earlier for linear response (all the other covariates, including meteorology and long-term trend, are kept the same) and then the three slopes β_1, β_2, β_3 combined across cities using the *tlnise* software. For each ozone level, we computed a posterior mean and a posterior standard deviation for the population-weighted average response, and based on that computed a pointwise 95% prediction interval. The results are shown in Table 6 and Figure 8, for both the all-year and summer-only estimates.

Except for the fact that we are plotting a piecewise linear rather than a smooth curve, the appearance of these plots is quite similar to Figure 3 of Bell et al. (2006). However, closer analysis shows that the estimates of the three slopes are quite variable, especially β_3. Figure 9 shows separate estimates and 95% prediction intervals for β_1, β_2, β_3, both nationally and regionally. There is still substantial regional

Table 6. Piecewise linear results based on 8-h ozone, controlled distributed lag model, NMMAPS meteorology, no PM_{10}.

	Original tlnise				Pop.-weighted Average			
Range	All-yr	RMSE	Summ	RMSE	All-yr	RMSE	Summ	RMSE
0-40 ppb.	0.157	0.094	0.128	0.123	0.194	0.081	0.147	0.113
40-60 ppb.	0.331	0.107	0.313	0.108	0.340	0.089	0.327	0.096
60-80 ppb.	0.325	0.178	0.369	0.178	0.306	0.157	0.350	0.159

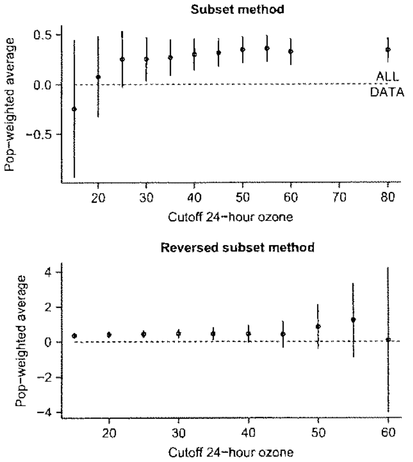


Figure 7. Top: The "subset approach" in which the 24-h ozone-mortality model is restricted to a subset of days below 15, 20, ..., 60 ppb, and the unrestricted estimate. This is the same as Figure 2 of Bell (2006) except that the calculation is in terms of population-weighted average rather than "national average" (but the appearance is very similar). Bottom: The same with the "reversed subset" approach, in which the data are subsetted according to all days greater than a given threshold, rather than all days less than a given threshold. The increasing width of the PIs as the threshold increases shows the uncertainty of estimating an ozone-mortality coefficient at high ozone levels.

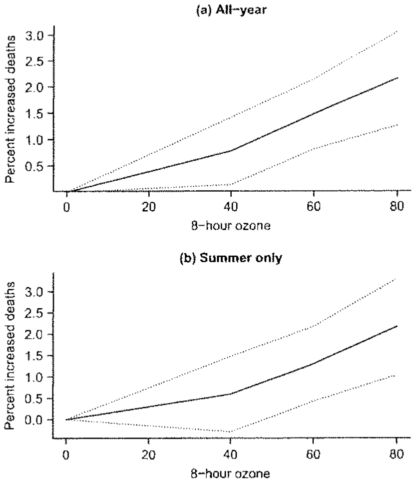


Figure 8. Estimates and pointwise 95% PIs assuming a piecewise linear exposure-response relationship with breaks at 40 ppb and 60 ppb 8-h ozone.

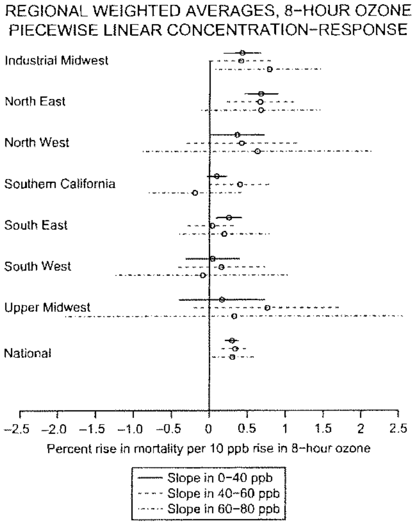


Figure 9. Regional slopes for piecewise linear approach.

variation; there is no clear indication that β_3 is the largest of the three coefficients (as one might expect if it were true that ozone toxicity is greater at higher concentrations) and it has by far the largest posterior standard deviation of the three estimates.

The Industrial Midwest is the only region with a statistically significant effect in 60–80 ppb according to this analysis.

Individual-city analyses

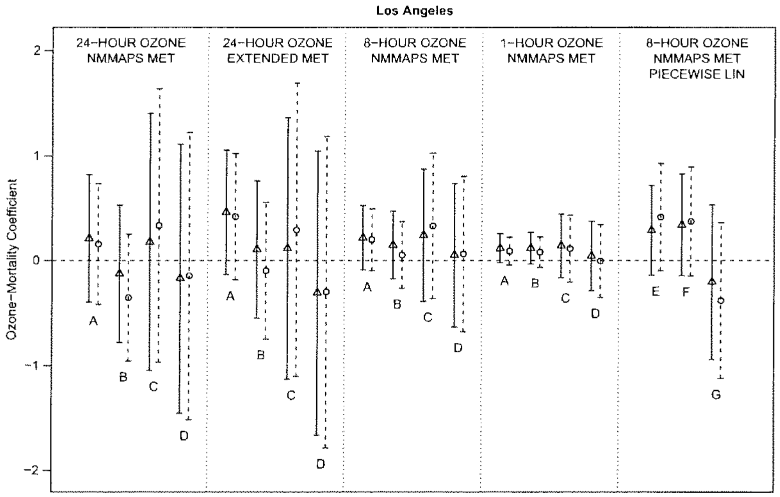
We select four cities to illustrate different types of results. For each city, the results of 38 analyses have been shown, including analyses that represent 24-h, 8-h, and 1-h ozone, the NMMAPS and extended meteorology models, all-year and summer data, analyses both with and without PM_{10} as a co-pollutant, and the piecewise linear as well as linear concentration-response curve. For each analysis, we present the posterior mean ozone-mortality coefficient and the boundaries of a 95% prediction interval. In cases where the prediction interval includes 0, the result should be interpreted as meaning that the ozone-mortality effect is not statistically significant in that city. All results are based on the standard two-stage analysis specified by Equations (1) and (2) for the national prior, or (2) and (3) (with x_c taken as a regional indicator variable) for the regional prior.

Los Angeles is the largest city in the study, with very high ozone levels, and if there were a cause-and-effect ozone-mortality relationship, one would expect it to show up in a wide variety of analyses. Despite this, no single analysis produces a clearly significant result, as shown in Figure 10.

Our previous results have shown New York and Chicago illustrating a strong ozone-mortality relationship. It is therefore no surprise that several analyses show significant results for both those cities (Figures 11 and 12). On the other hand, to take an example of a western city that also has high ozone levels, for Denver (Figure 13), none of the statistical analyses shows a significant relationship. Similar results, showing essentially no significant result for the posterior distributions at the individual-city level, have been obtained for other large western cities (e.g., Albuquerque, Phoenix, Salt Lake City, Seattle) and east coast cities in the south (e.g., Atlanta, Miami). These results reinforce the fact that the ozone-mortality effect is concentrated within certain regions of the United States, and cities outside those regions show little if any effect.

Discussion

Multicity time-series studies have come to be viewed as the gold standard of air pollution health research. They are superior to single-city analyses, which typically exhibit too much statistical variation from city to city for a clear conclusion to be drawn. This is apparent from Figure 1a, in which the individual estimates range from −4.1% to +6.3% rise in mortality per 10 ppb rise in 24-h ozone, with a median standard error of 1.4. Moreover, single-city results, including which cities



Point estimates and 95% Prediction Intervals for 3 ozone metrics (24-hour, 8-hour, 1-hour), and 2 meteorologies (NMMAPS, extended). Triangles/solid lines: national prior. Circles/dashed lines: regional prior.
A: Full dataset; B: Summer only; C: PM10 not included but analysis restricted to days on which PM10 available;
D: PM10 included; EFG: Piecewise linear model slopes for 0–40 ppb (E), 40–60 ppb (F), 60–80 ppb (G)

Figure 10. City plot for Los Angeles.

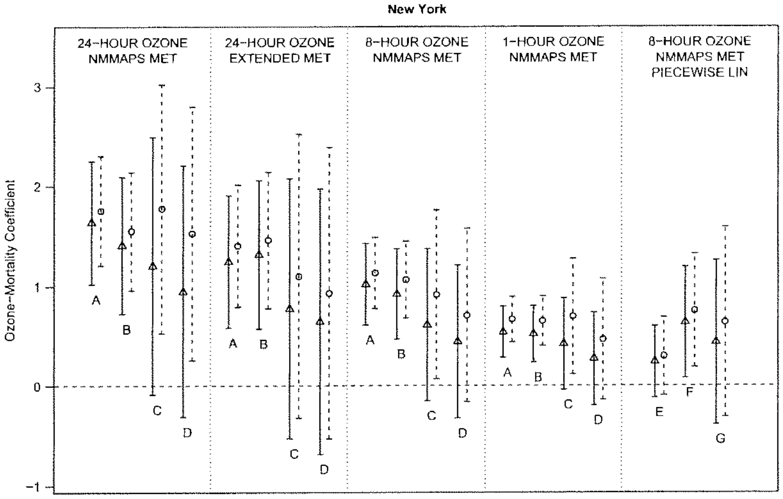
emerge with statistically significant effects, are highly sensitive to statistical modeling assumptions.

Multicity time-series studies are also widely considered superior to meta-analyses. The distinction is that a multicity time-series study uses raw data from each city in the study, which it analyzes using uniform statistical methods, whereas a meta-analysis combines data from previously published studies. There are two kinds of potential bias in this approach: publication bias (arising from the tendency of researchers to publish only those results in which they found a statistically significant effect) and model selection bias (selecting the statistical model to maximize the estimated effect, separately for each city). These difficulties are apparent in the three ozone meta-analyses that were published together in *Epidemiology* in 2005 (Bell et al. 2005; Ito et al. 2005; Levy et al. 2005). In particular, Bell et al. (2005) directly compared NMMAPS multicity results with a meta-analysis based on previously published results for the NMMAPS cities, in some cases finding effects that were as large as three times greater in the meta-analysis (allowing for differences in the ozone metric and units of measurement), which the authors themselves attributed to the likely effects of publication bias.

Multicity time-series studies were first used to study the mortality and morbidity effects of PM_{10} (Dominici et al. 2000, 2002, 2003;Samet et al. 2000a, 2000b). They have been extensively used in the analysis of ozone and mortality—apart from the papers already cited, a smaller multicity study was included in Ito et al. (2005), an earlier version of the NMMAPS analysis in Huang et al. (2005), and a similar European study in Gryparis et al. (2004). They were also used in a widely cited study about $PM_{2.5}$ and hospital admissions (Dominici et al. 2006).

We believe multicity time-series studies may also suffer from serious difficulties, as illustrated by our reanalysis of the NMMAPS data on ozone and mortality. One issue is the sensitivity of the results to statistical modeling assumptions, such as the functional form of meteorological adjustment, the inclusion of co-pollutants as confounders and effect modifiers, the choice of ozone metric and the use of a linear concentration-response model. In addition, the final result of a multicity time-series study is usually quoted in some form of national average. In many cases, this is calculated through a Bayesian hierarchical modeling procedure, though virtually identical results are obtained through a non-Bayesian restricted maximum likelihood (REML) procedure.

However, quoting a single value as a national average is misleading if there is substantial heterogeneity. We have investigated these issues by calculating regional estimates, drawing spatial maps, looking at the dependence of individual city results on demographic and environmental covariates (between-city effect modifier analyses), and by looking



Point estimates and 95% Prediction Intervals for 3 ozone metrics (24-hour, 8-hour, 1-hour), and 2 meteorologies (NMMAPS, extended). Triangles/solid lines: national prior. Circles/dashed lines: regional prior.
A: Full dataset; B: Summer only; C: PM10 not included but analysis restricted to days on which PM10 available;
D: PM10 included; EFG: Piecewise linear model slopes for 0–40 ppb (E), 40–60 ppb (F), 60–80 ppb (G)

Figure 11. City plot for New York.

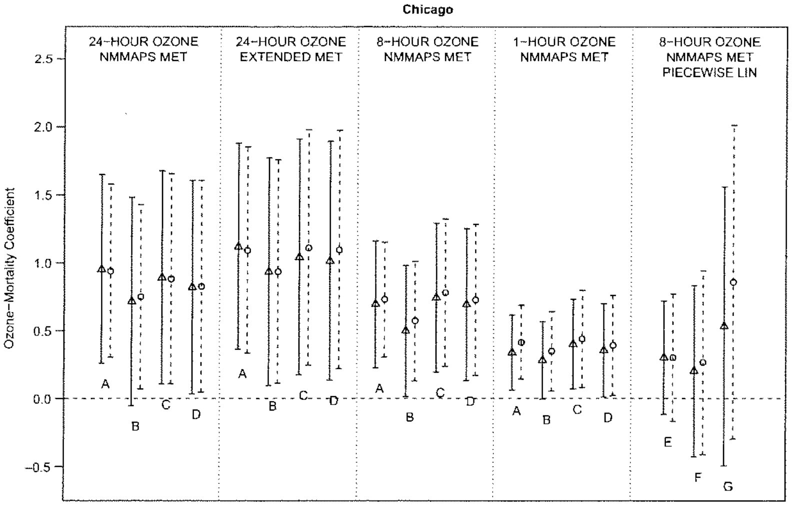
in depth at some of the posterior analysis results for four individual cities. In the following discussion, we summarize our main conclusions under each of these headings.

In Figure 1, we showed the raw (MLE) estimates of the regression coefficients, together with the posterior estimates under two priors (national and regional), and posterior 95% intervals based on the national prior. The results based on the national prior are the same as in Figure 2 of Bell et al. (2004). The fact that individual-city posterior means are sensitive to which of the two forms of prior is chosen shows that the choice of prior cannot be ignored in evaluating this kind of analysis. Given that we present substantial evidence later in the paper that the regional differences are real, it might be more logical to prefer the regional prior.

In presenting the different results for national means, we have noted that the posterior mean of the "national average" parameter μ (in (1)) is closer to the unweighted mean of the individual-city estimates than it is to a mean weighted by population or (what is almost the same thing) by the inverses of the individual-city variances. This seems counterintuitive, because there is large variability in the sizes of individual cities and it seems both logical and inevitable that the largest cities should have a strongest influence on the overall average. However, the result may be explained by noting that, conditionally on τ^2, the estimate of μ is the weighted average with weights proportional to $1/(s_i^2 + \tau^2)$, in the notation of (1) and (2). If τ^2 is large relative to the individual s_i^2, the Bayes estimate will be approximately the unweighted mean. This might be a reasonable thing to do if we were selecting cities at random from a very large number of cities (the implicit if unstated assumption in (1)), but that is not valid here because the selection of cities is very clearly not random.

This discussion highlights the difficulty of interpreting a "national" ozone effect estimate in cases where there is substantial intercity heterogeneity among estimated ozone-mortality effect coefficients. We caution, again, that any national summary, even a population-weighted average, will necessarily conceal the still-unexplained heterogeneities. Further, we believe that the heterogeneity and sensitivity of ozone effect estimates to a variety of covariates leaves open the issue of whether or not ozone is causally related to mortality. Consequently, the question arises whether any particular ozone-mortality effect estimate can reliably be used to predict mortality reductions that would ensue from specific ozone reductions.

For the purpose of computing summary results where these are needed, we propose a population-weighted average, but without any implication that this represents a causal association. Some cities, such as Los Angeles and Denver, do not show any statistically significant effect of ozone on mortality. Conversely, the use of a national coefficient for a



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A: Full dataset; B: Summer only; C: PM10 not included but analysis restricted to days on which PM10 available;
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Figure 12. City plot for Chicago.

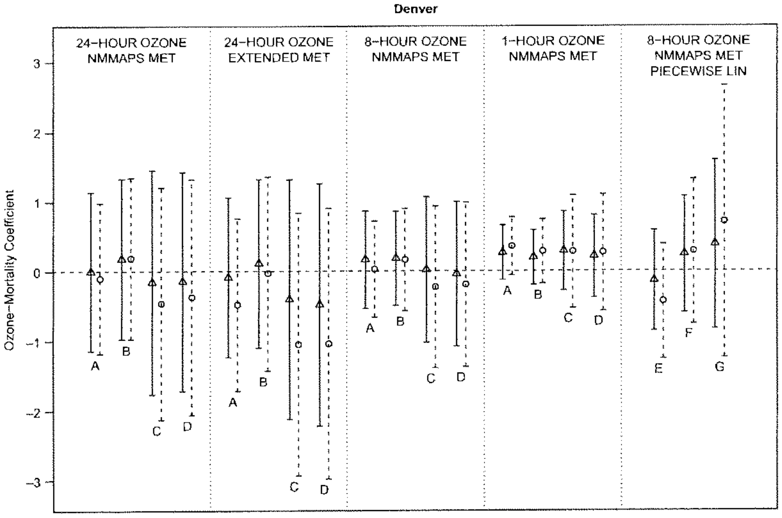
city like New York or Chicago may underestimate the effect of ozone as compared to use of a city specific coefficient.

We have examined the sensitivity of the individual-city estimates to alternative specifications of meteorology and the inclusion of co-pollutants. The effect of meteorology has already been examined extensively in previous studies; for example, Ito et al. (2005) used four meteorological adjustments and found that the overall ozone-mortality coefficient varied by a factor of 2 over the models studied; however, the smallest of these was for the model that essentially replicates the meteorology model of Bell et al. (2004). Bell et al. (2004) and Schwartz (2005) argued that the ozone-mortality effect is not changed by the exclusion of hot days. As a comparison, we reran some of our models deleting the hottest 1% of days within each city, with no change in the results. However, one caution we would note is that it is necessary to exclude days with very unusual mortality levels, such as occurred during the Chicago heatwave of July 1995, because such values are highly influential on the regression estimates. In fact Bell et al. (2004) already applied such a correction, as became clear on detailed examination of their computer code, though this was not mentioned in their paper.

We have considered alternative specifications of meteorology, including an "extended meteorology" model that has a distributed lag form similar to that used for ozone. In some cases, this results in a reduction of the estimated ozone effect, implying a partial temperature confounding that was not accounted for in earlier analyses.

We looked at the possibility of a confounding effect due to PM_{10}, concluding that the overall ozone-mortality coefficient is reduced between 22% and 33% when PM_{10} is included in the model, despite the fact that in many cities, PM_{10} is only sampled once every 6 days. It is difficult to make precise statements concerning the statistical significance of this result, given the large posterior standard deviations, but the result has been observed persistently across numerous analyses. It therefore seems doubtful to us that it is spurious, though it is clear that our interpretation of this result is different from that of Bell et al. (2004, 2007). On the other hand, Franklin and Schwartz (2008) found an even larger confounding effect based on a different dataset using sulfate particles.

Other authors who have considered the confounding effect of PM_{10} as a co-pollutant include Huang et al. (2005), who analyzed a subset of the NMMAPS database; when both ozone and PM_{10} were included in the model at lag 2, there was a decrement in the ozone-mortality effect similar to that reported here, but at other lags, the effect was smaller or nonexistent. Schwartz (2005) also looked at PM_{10} confounding in his case-crossover analysis, concluding there was no effect. The meta-analyses (Bell et al. 2005; Ito et al. 2005)



Point estimates and 95% Prediction Intervals for 3 ozone metrics (24–hour, 8–hour, 1–hour), and 2 meteorologies (NMMAPS, extended). Triangles/solid lines: national prior. Circles/dashed lines: regional prior.
A: Full dataset; B: Summer only; C: PM10 not included but analysis restricted to days on which PM10 available;
D: PM10 included; EFG: Piecewise linear model slopes for 0–40 ppb (E), 40–60 ppb (F), 60–80 ppb (G)

Figure 13. City plot for Denver.

generally reported that inclusion of PM_{10} did not have a great overall effect on the results of the meta-analyses, but Bell et al. (2005) reported that where PM_{10} was included, its effect was almost always to lower the estimated ozone-mortality effect.

We also looked at temperature, PM_{10}, and SO_2 as within-city effect modifiers. For temperature, we found that in summer, the ozone-mortality coefficient is higher when temperature is above the median than when it is below. However, a more detailed regional analysis (not tabulated) showed that this effect is statistically significant only in the North East and Industrial Midwest regions. For PM_{10}, there is a statistically significant effect modifier relationship for all three ozone metrics and both all-year and summer-nnly data. Other calculations have shown that there is also some evidence of a regional effect here, strongest in the North East. The evidence for SO_2 being an effect modifier is less clear cut, because the relationship was significant only for 24-h ozone and all-year data. Taken together, these results imply that the influence of meteorology and co-pollutants on the ozone-mortality association cannot be ignored.

Our results on temperature as an effect modifier are consistent with those of Ren et al. (2008), who also used the NMMAPS data but treated the ozone, meteorology, and long-term trend effects in quite different ways from the analysis here. Ren et al. confined their study to summer data and to two regions: a combination of our Industrial Midwest and North East regions (that they called "northeast"), and the South East region (the same as ours). They stratified temperature into three ranges: below the first quartile, between the first and third quartiles, and above the third quartile. They then computed combined estimates of the ozone-mortality coefficient in each of the three ranges. For their northeast region, they claimed the ozone-mortality effect is by far the largest in the highest range of temperatures (above the third quartile). For the South East, they essentially found no difference in the ozone-mortality coefficient among the three ranges of temperature. These results are consistent with ours, which show temperature is a statistically significant effect modifier for summer data in the North East and Industrial Midwest, but not in the other five regions (including the South East).

On the more general effect of changing ozone metrics, we found that single-city ozone-mortality coefficients computed under the 24-h, 8-h, and 1-h ozone metrics are quite highly correlated (0.7-0.8) in either the raw or posterior mean estimates, but the association is certainly not perfect (Figure 3). Previous authors have used conversion factors to compare results in different metrics; for example, Bell et al.

(2005) used the ratios 20:15:8 for the means of 1-h, 8-h, and 24-h ozone. However the actual ratios of these means for different cities vary substantially.

We found significant regional and spatial variability in the ozone-mortality coefficient, using seven regions for the continental United States that had earlier been defined for PM_{10} studies (Samet et al. 2000b; Dominici et al. 2002, 2003). The city of Honolulu was excluded from all analyses that involved regional variables. Similar regional results for 24-h ozone, all-year analyses, were reported by Bell and Dominici (2008); as far as we are aware, this was the first explicit discussion of regional variation in the ozone-mortality coefficient, though such an effect is apparent from close scrutiny of Figure 2 of Bell et al. (2004). Our results showed that this is a persistent effect across all three ozone metrics and both all-year and summer-only data; later (Figure 9) we also showed that a regional effect also exists in the piecewise linear analysis. The overall pattern of these results is that the North East and Industrial Midwest regions have by far the largest ozone-mortality associations; there is also a smaller but in many instances statistically significant association for the South East (that we believe is largely due to the cities in Texas, especially Houston and Dallas/Fort Worth). The piecewise linear analysis (Figure 9) implies that the result for the South East may be entirely due to the ozone-mortality association at low ozone levels, below 40 ppb. The fact that clear differences exist for the individual-city results in different regions (Figures 10–13) also reinforces the conclusion that the inter-region differences are both statistically and practically significant.

Spatial patterns have previously been shown for PM_{10}-mortality effects (Dominici et al. 2002). An online figure posted with Bell and Dominici (2008) depicted the spatial variability of the estimated effects, though they claimed there was no evidence of a spatial pattern. They did not, however, make explicit use of spatial correlation and kriging techniques. Our analyses leading to Figure 6 brings out the spatial pattern much more sharply than previous analyses. It naturally raises the question of what could be the cause of such strong spatial effects.

The main conclusion of Bell and Dominici (2008) was that differences among cities could be explained in terms of (between-city) effect modifiers. Effect modifiers can be classified broadly into three types. Demographic variables (e.g., racial or socioeconomic) might be indicative of vulnerable subgroups of the population. The other two broad classes are those associated with exposure and with possible co-pollutants. The presence of SO_2 among the significant effect modifiers suggests a co-pollutant effect, though we did not find such a strong effect for SO_2 when treated as a within-city effect modifier. In contrast, for PM_{10} the effect is the other way round: significant as a within-city modifier, but not as a between-city modifier. For temperature, we have observed a positive association (in summer) when treated as a within-city modifier, but there is a negative association when temperature is treated as a between-city effect modifier, which suggests that temperature as a between-city effect modifier could be a proxy for something else (such as AC use). Alternatively, it is possible that temperature (like latitude and longitude, which were also statistically significant effect modifiers) is just a proxy for a broad spatial pattern that, as we saw earlier, leads to significantly higher ozone-mortality coefficients in the North East and Industrial Midwest regions.

The two variables related to transport presumably reflect exposure—those taking public transport spend more time in the open air and are therefore more exposed to ozone. Air conditioning has a similar interpretation—people who live in air-conditioned houses are less exposed to ambient ozone in summer. However, we found a much stronger effect by separating the air-conditioning variable into one based on central AC and another based on the use of window AC units. For central AC, we found a statistically significant negative association, consistent with Bell and Dominici for the 24-h ozone all-year analysis but also extending to the other five analyses in Table 2. But there is a stronger *positive* association between the proportion of houses using window AC in a city and the ozone-mortality coefficient in that city. It is known that homes with central AC tend to have lower air exchange rates and hence also lower indoor to outdoor ozone ratios. Because outdoor ozone is the main source of indoor ozone, this would imply that actual ozone exposures are lower in houses with central AC (Weschler 2000, 2006). It therefore seems plausible that houses with window AC have a higher indoor-to-outdoor ozone ratio and therefore the residents experience higher ozone exposure. Further evidence to support this includes the fact that window AC units contain a 'vent' option that allows addition of outdoor 'make-up' air to recirculated conditioned air, actively increasing room/home air exchange rates, although at the expense of reduced cooling and energy efficiency; central AC units usually lack such options and are often installed in relatively tight, well-insulated homes with low air exchange. Also, open windows are found more common (and likely air exchange rates higher) in houses with window AC or no AC than homes with central AC (Johnson and Long 2005). Other possible confounding issues may arise from indoor temperature and dewpoint being different between houses with and without AC.

The variables associated with residential mobility could be demographic or exposure-related. In their reanalysis of the American Cancer Society cohort study, Krewski et al. (2000) noted that population change is correlated with standardized mortality rates, and suggested as one possible explanation that healthy people are more likely to move. However, it is also possible that this reflects exposure, older houses being less well insulated and perhaps also less likely to have central air conditioning. All four "residential mobility" variables in Table 5 are positively correlated with central AC usage and negatively correlated with window AC use.

The fact that several variables related to ozone exposure could be significant effect modifiers is consistent with results of Koutrakis et al. (2005) and Sarnat et al. (2006), which demonstrated a low correlation between personal and ambient levels of ozone, in contrast to PM_{10} or $PM_{2.5}$ where the correlations are much higher. The impact of these findings for regulations is unclear, but it seems to us that there is a need to recognize the different degree of ozone association in cities such as New York and Chicago compared with many others where the associations are much smaller. It is also possible that the fact that ozone-mortality effects have been generally reported higher in European cities (Gryparis et al. 2004) compared with the United States may also be associated with variables such as public transport, or with much lower usage of AC, although there are other difficulties in comparing the studies, such as the use of different ozone metrics and statistical methods, and different policies in the United States and Europe regarding the siting of ozone monitors.

Our conclusions from this part of the analysis are as follows. First, the presence of several statistically significant effect modifiers confirms that the variation of the ozone-mortality coefficient over cities is not random, and therefore throws further into question the validity of computing national risk estimates. However, the analysis does not clearly identify any single effect modifier as the one most likely to have a cause and effect interpretation. Variables that are indicators of race or socioeconomic status, as highlighted by Bell and Dominici (2008), seem to us to be spurious. The other variables seem to suggest either a co-pollutant effect, or variations in personal exposure to ozone. In either case, the true causal mechanism that leads to an observed ozone-mortality association is unresolved.

The final part of our discussion concerns the possibility of a nonlinear exposure-response association, where "response" here is generally interpreted as the logarithm of mortality rate at a given ozone level. Previous discussion of this issue has often been focused on the apparent nonexistence of an ozone threshold (e.g., NRC 2008), but it is also important to consider the broader implications of a nonlinear association, such as its impact on risk assessments that try to evaluate the benefits of ozone reductions across certain ranges. Bell et al. (2006) presented a "subset analysis" that showed the effect of ozone persists to very low levels. We have essentially replicated their results, but for comparison purposes, we also show a "reverse subset" analysis that confirms the increasing uncertainty of the ozone-mortality association as we restrict to moderate or high levels of ozone.

The finding of a statistically significant effect at very low ozone levels is mysterious, because direct studies of human lung function response to ozone do not show any effect at 40 ppb (Adams 2002, 2006). Other authors have questioned the biological plausibility of associations at very low ozone levels (Vedal et al. 2003). The biologic plausibility argument is delicate in that it refers to human personal exposure as opposed to an ozone metric derived from monitored ambient concentrations. A statistically significant linear response at low ambient ozone might be less surprising if actual personal exposures were biologically meaningful and highly correlated with ambient ozone at low ambient concentrations. However, at this time, the concern of Vedal et al. is relevant and removing the objection of biologic implausibility requires demonstrating that (a) actual personal exposures at low levels are biologically meaningful and (b) substantial personal exposure-ambient correlation exists in the low-ambient range. We believe it is reasonable to hypothesize that the variability across cities of the ozone-mortality coefficient estimates is linked to variability across cities in the relationship between personal exposures and the monitored ozone metric.

Moreover, although there remains extensive spatial variability (in the range 15–50 ppb) in estimates of policy-relevant background ozone level (Fiore et al. 2002, 2003; Oltmans et al. 2008), it seems likely that 24-h ozone levels below 30 ppb or 8-h ozone levels below 40 ppb would be below the level plausibly affected by any currently proposed ozone regulation.

Plots of total relative risk (compared with zero ozone) across different ozone ranges appear to show a steady increase in risk with ozone level, as in our Figure 8 or Bell et al.'s (2006) Figure 3. However, this could be misleading because it appears that most of the contribution to the overall risk is from relatively low-ozone days, many of them below background level. The ozone range most likely to be affected by regulation is that between 60 and 80 ppb, but here the effect is much more uncertain (Figure 7), and the picture is clouded still more by the regional variation.

Summary and conclusions

The basis for the national effect estimates published by Bell and others is questionable in the face of clear evidence that the effect is not homogeneous. We propose the population-weighted average as a more meaningful summary of a heterogeneous effect, but such a summary is specific to the group of cities considered: there is no implication or even expectation that the same numerical result would apply for a different population base, even if the methods of data collection and analysis were essentially the same. Also, the estimates do not translate evenly from one ozone metric to another.

There is clear evidence of a PM_{10} co-pollutant effect that has been understated or misinterpreted in previous publications. Given that in many cities PM_{10} is only available 1 day in 6, and is probably not the most effective measure of a particulate matter effect, the true influence of co-pollutants could be much greater than this. We also find that temperature, particulate matter, and sulfur dioxide all act as (within-city) effect modifiers, though the temperature effect is confined to the North East and Industrial Midwest regions in summer, and the effect for sulfur dioxide may be spurious given that it only applies to the 24-h ozone metric.

The nonlinear analysis shows that much of the evidence for an ozone-mortality relationship in fact comes from the low-ozone days, but human studies do not support an ozone effect at such low ozone levels. It is possible that the appearance of an association at low ozone levels may be due to the effect of co-pollutants, or an artifact caused by differences between personal and ambient exposure. If we try to estimate the ozone-mortality effect restricted to higher levels of ozone that might be directly affected by new regulations, the uncertainty is much greater and there is still evidence of regional variability.

The regional estimates and single-city analyses demonstrate that the evidence for any ozone-mortality effect is weak away from a central band across the country that stretches from Houston to New York.

A number of between-city effect modifiers have been identified that may explain some of the spatial variability. No single effect modifier is primarily responsible; one that turned out highly significant was the proportion of window AC units, and another was residential mobility. However, the mechanism by which such factors influence ozone epidemiology is still very unclear. We do believe, however, that this kind of effect modifier has a stronger influence than those based on race or socioeconomic factors.

There are other methodological issues that have not been discussed in this paper, but that could affect the results. For example, the long-term trend part of the model exactly follows Bell et al. (2004), but it is known from studies of other air pollution effects (Peng et al. [2006] in the case of PM_{10}, Ostro et al. [2006] in the case of $PM_{2.5}$) that model results may be sensitive to the degrees of freedom and other aspects of the specification of this component. We have not considered specific-cause mortality effects, such as cardiovascular or chronic obstructive pulmonary disease (COPD) mortality. It also remains to explore many alternative aspects of copollutant effects, including nonlinear specification of the ozone-mortality relationship in the presence of an effect modifier.

In summary, it is our view that estimates of the association between ozone and mortality, based on time-series epidemiologic analyses of daily data from multiple cities, reveal important still-unexplained inconsistencies and show sensitivity to modeling choices and data selection. These inconsistencies and sensitivities contribute to serious uncertainties when epidemiological results are used to discern the nature and magnitude of possible ozone-mortality relationships or are applied to risk assessment.

Appendix 1: Derivation of REML estimator

Equations (1) and (2) may be combined to imply that $t_c \sim N[\mu, s_c^2 + \tau^2]$ independently for each city c. The weighted least squares estimator of μ is $M = [\sum t_c/(s_c^2 + \tau^2)]/[\sum 1/(s_c^2 + \tau^2)]$. If we let T denote the vector of all the t_c, and if we generalize to the case $T \sim N[X\beta, H]$ for some covariate matrix X with n rows and $q < n$ columns and of rank q, β a vector of regression parameters of dimension q, and H a covariance matrix with n rows and n columns, then by Equation (3) of Harville (1974), the logarithm of the restricted likelihood is given by

$$\begin{aligned}&-½(n-q)\log(2\pi)+½\log\det(X^T X)\\&-½\log\det(X^T H^{-1}X)-½\log\det(H)-½R\end{aligned} \tag{5}$$

where R is the generalized residual sum of squares, $R = (T - Xb)^T H^{-1}(T - Xb)$ and $b = (X^T H^{-1}X)^{-1}X^T H^{-1}T$ is the generalized least squares estimator of β. For the analysis where there is no covariate, we specialize (5) to the case when $q = 1$, X is a column vector of ones, β is the scalar parameter μ, H is a diagonal matrix whose c'th diagonal entry is $s_c^2 + \tau^2$. Then R is the weighted sum of squares of residuals $\sum (t_c - M)^2/(s_c^2 + \tau^2)$ and if we ignore the first two terms of (5) (which do not depend on μ and τ^2), then maximizing (5) is equivalent to minimizing

$$\log[\Sigma 1/(s_c^2+\tau^2)]+\Sigma\log[1/(s_c^2+\tau^2)]+\mathrm{R} \tag{6}$$

which is a function of τ^2 alone; in other words, we choose τ^2 to minimize (6). This is then called the REML estimator of τ^2. Conditionally on τ^2, we then estimate μ by M as given previously, with an estimated variance of $1/[\sum 1/(s_c^2 + \tau^2)]$. The square root of this then gives the standard error of μ.

For the effect modifier analysis across cities, we write the regression model in the form $E(t_c) = \beta_0 + \beta_1 x_c$, where x_c is the effect modifier in city c; estimates β_0, β_1, of the regression coefficients β_0, β_1 are obtained by weighted least squares with weights $1/(s_c^2 + \tau^2)$, and we calculate $R = \sum (t_c - \beta_0 - \beta_1 x_c)^2/(s_c^2 + \tau^2)$. We then select τ^2 to maximize (5), which in this instance is equivalent to minimizing $\log[\sum(1/(s_c^2 + \tau^2)) \sum(x_c^2/(s_c^2 + \tau^2)) - (\sum(x_c/(s_c^2 + \tau^2)))^2] + \sum\log(s_c^2 + \tau^2) + R$.

Appendix 2: Estimation of population-weighted means

We assume the standard hierarchical model defined by Equations (1) and (2). Suppose we want to estimate $\sum w_c \theta_c$ for given weights w_c—in the context of this paper, we are particularly interested in the choice when w_c is proportional to the population of city c. We can formulate this as a problem in universal kriging, see, e.g., Cressie (1993) or Stein (1999). Suppose Y is a vector of observations with mean $X\beta$ and covariance matrix V (here $X\beta$ refers to some matrix of covariates X and an unknown linear regression coefficient β). Suppose Y_0 is some as yet unobserved scalar quantity with mean $x_0^T\beta$ and variance v_0 (x_0, v_0 known, β unknown). Also assume the vector of covariances between Y and Y_0 is w_0. Then the optimal linear predictor of Y_0 is of the form $\lambda^T Y$ where $\lambda = V^{-1}w + V^{-1}X(X^T V^{-1}X)^{-1}(x_0 - X^T V^{-1}w)$, and the corresponding mean squared prediction error is $v_0 - w^T V^{-1}w + (x_0 - X^T V^{-1}w)^T(X^T V^{-1}X)^{-1}(x_0 - X^T V^{-1}w)$. In the present case, we identify Y with the vector of city-specific regression coefficients from the first stage of the analysis, whose means are all μ (i.e., X is a column vector of ones, $\beta = \mu$) and whose covariance matrix V is diagonal with diagonal entries, $s_1^2 + \tau^2$, $s_2^2 + \tau^2$, ..., where s_1^2, s_2^2... are the individual standard errors and τ^2 is the intercity variance. We identify Y_0 with $\sum w_c \theta_c$, x_0 with w (i.e., the vector of weights w_c), and v_0 with $\tau^2 \sum w_c^2$. Routine algebraic rearrangement then shows the optimal predictor and its mean squared prediction error are of the form given.

Appendix 3: Spatial analysis

In this appendix we briefly outline the method for computing Figure 6.

The approach is an extension of that used in Appendix 1 to allow for spatial dependence in the prior distribution for θ_c. We extend (2) and (3) to

$$T \mid \Theta \sim N[\Theta, W], \tag{7}$$

$$\Theta \sim N[X\beta, H] \tag{8}$$

where N represents the multivariate normal distribution, T is the vector of t_c, Θ is the vector of θ_c, $X\beta$ is the linear mean, and W and H are covariance matrices. We assume W is known—consistent with (2), W is the diagonal matrix with s_c^2 in the c'th diagonal position—but H is taken to be a parametric spatial covariance matrix—for the examples given here, this was assumed to be of the "Gaussian" covariance form with no nugget, after trying several alternatives, see, e.g., Cressie (1993) or Stein (1999) for an introduction to spatial covariances and their application in spatial prediction.

Combining (7) and (8) into a single equation, we have

$$T \sim N[X\beta, H + W],$$

from which β and the parameters of H may be estimated by the REML method, using (5) again with H replaced by $H + W$. Conditional distributions for the components of Θ given T, both at the actual city sites and elsewhere, are then calculated by the procedure known as universal kriging, which is described in detail in books on spatial statistics, including Cressie (1993) or Stein (1999).

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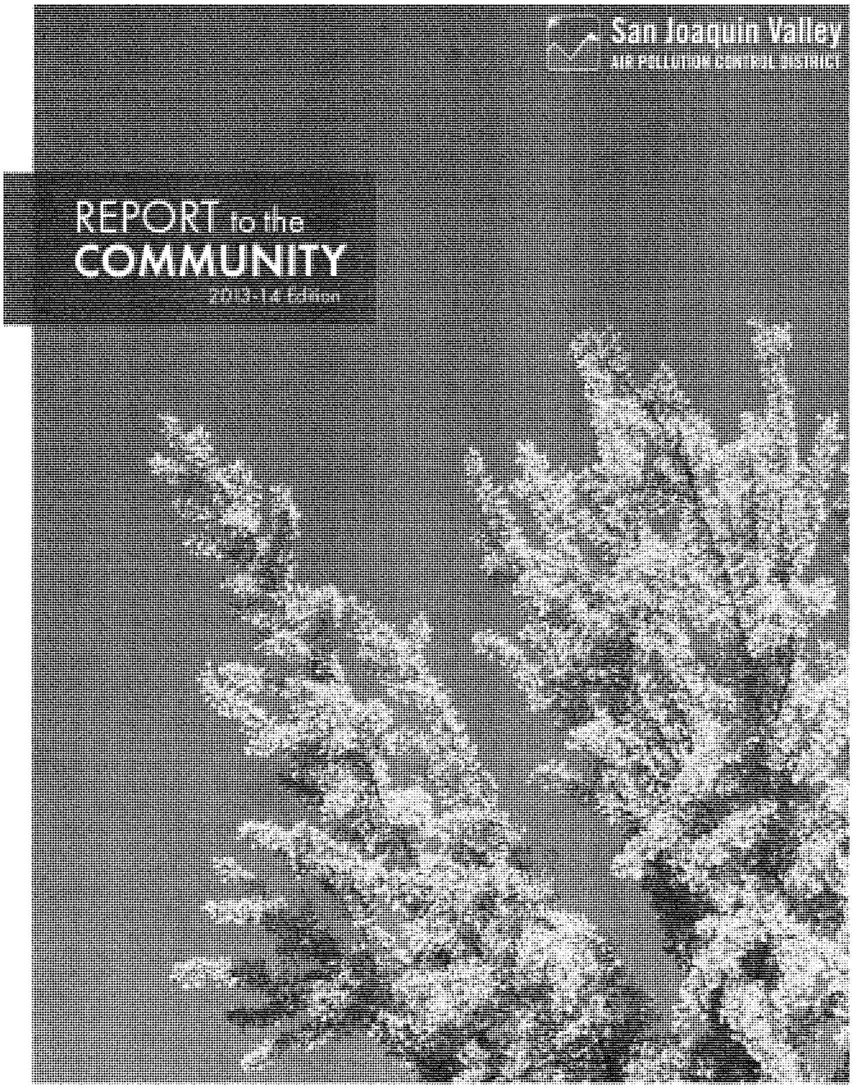

San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

REPORT to the
COMMUNITY
2013-14 Edition

Message from the
Air Pollution Control Officer

Great work, San Joaquin Valley!

As the work of cleaning up the Valley's air continues, we are delighted to pause to savor a historic accomplishment.

In 2013, the Valley air basin became the first in the country to advance from a classification of extreme non-attainment for a pollutant to achieving a difficult health standard.

This is, indeed, a moment worth celebrating. Valley residents can take pride in our collective efforts to continuously improve air quality through groundbreaking strategies that are rooted in good science and common sense.

Since the 1-hour ozone standard was established by the federal Environmental Protection Agency, the Valley has been, dubiously, among the top several air basins throughout the nation in terms of exceedances. But in the past few years, all this changed.

Despite natural events including triple-digit temperatures and wildfires, 2013 was the cleanest year on record for ozone. The progress has been remarkable. In 1996, the air basin experienced 281 hours over the standard. In 2012, that number plummeted to seven hours over the standard. And last year, we had zero hours that exceeded the health standard.

How did this happen? Through nothing less than the concerted, relentless, unwavering efforts between and among all the businesses and residents of the Valley. This accomplishment, which dramatically improves the quality of life for everyone who lives and works here, required billions of dollars in clean-air investments, long-term behavior changes, and most of all, a fundamental understanding of the importance of attaining this health goal for both health and economic vitality.

The Valley is challenged by many forces out of anyone's control, such as our unique geography: a bowl shape surrounded by mountains, resulting in long, sunny days and temperate winters, which provides the best growing conditions in the nation but also, unfortunately, provides an ideal environment for trapping and retaining emissions. Added to the endemic economic challenges we have, these conditions can seem insurmountable in our quest to advance to clean air.

But as the Valley's people have demonstrated time and again, our greatest natural resource is our "can-do" attitude matched with determination, sacrifice, and hard work. This "can-do" attitude has produced a truly remarkable achievement that we can all be very proud of, and that will serve, once again, as an example to the rest of the country of what can be achieved when a region comes together for the common good.

As we chronicle the past year of air quality progress, we are heartened by this victory, and confident in our ability to meet our remaining challenges.

Seyed Sadredin

Seyed Sadredin

Executive Director/Air Pollution Control Officer

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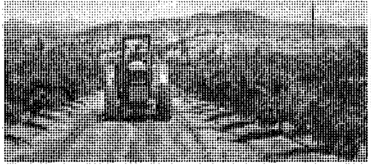
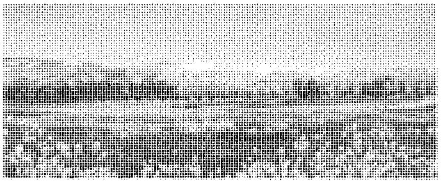
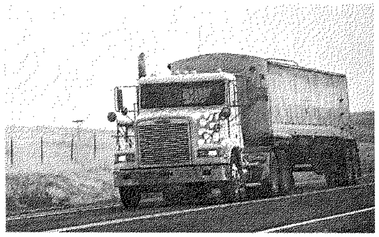
pg 10 Continuing to Invest in our Valley



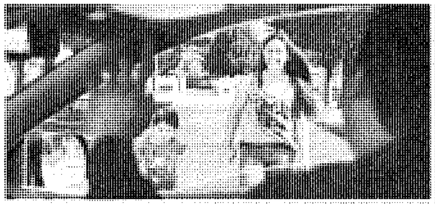


pg 3 1hr Ozone Attainment



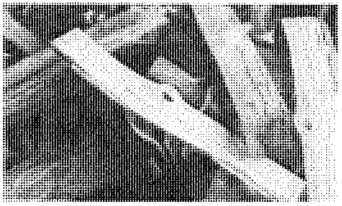
CONTENTS

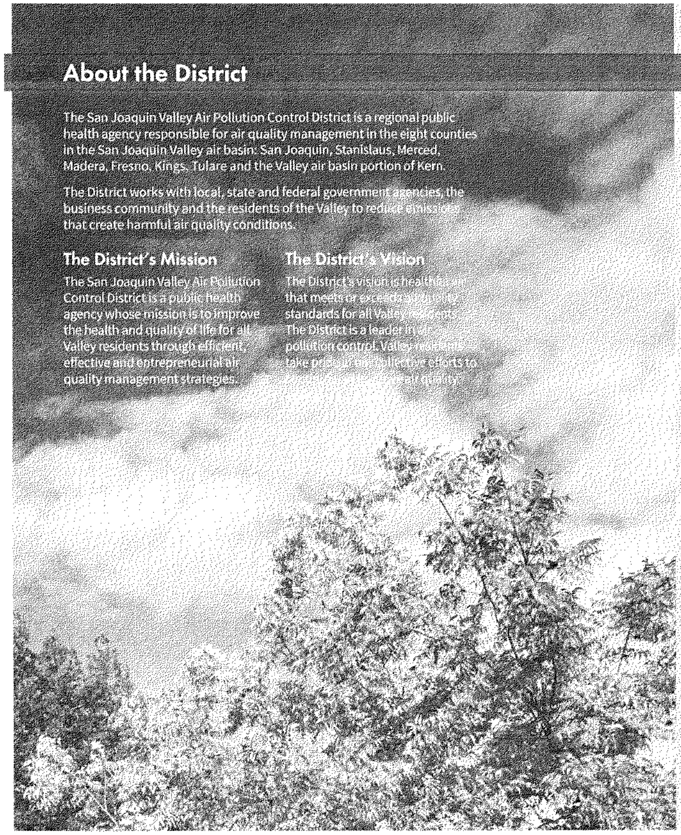
Inside Cover Message from the Air Pollution Control Officer
i Governing Board
1 About the District
1 The District's Mission
1 The District's Vision
2 The District's Core Values
3 1hr Ozone Attainment
5 Arvin Ozone Saturation Study
6 Transboundary Ozone
7 Ozone Trends
8 PM2.5 Trends
9 New Risk Assessment Guidelines from CAL/EPA
10 Continuing to Invest in our Valley
11 Grants
14 Federal Government Recognizes Incentive Programs
14 District Administers School Bus Program for other California Air Districts
15 Assisting Valley Environmental Justice Communities
  15 Tune-In, Tune-Up
  16 Environmental Justice Advisory Group
  16 Enhanced Public Outreach for Permitting
17 District Offers Assistance to Truckers
19 Hydraulic Fracturing
21 Vehicle Idling
22 Wood Burning Assessment Foothill Communities
23 Online Complaint Reporting
23 Health Risk Reduction Strategy
24 Improving Residential Wood Burning Rule
24 Action at State and Federal Levels
26 Overview of District's Operations
27 Streamlining & Efficiency
  30 Administration
  31 Rules & Regulations
  33 Permitting
  35 Enforcement
  37 Air Monitoring
  38 Legal Activities
  39 Information Technology
  40 Outreach and Communications
43 Sources of Pollution
45 District Employees Give Back to the Community
46 On the Radar



pg 21 Impacts of Vehicle Idling

pg 23 Health Risk Reduction Strategy





About the District

The San Joaquin Valley Air Pollution Control District is a regional public health agency responsible for air quality management in the eight counties in the San Joaquin Valley air basin: San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare and the Valley air basin portion of Kern.

The District works with local, state and federal government agencies, the business community and the residents of the Valley to reduce emissions that create harmful air quality conditions.

The District's Mission

The San Joaquin Valley Air Pollution Control District is a public health agency whose mission is to improve the health and quality of life for all Valley residents through efficient, effective and entrepreneurial air quality management strategies.

The District's Vision

The District's vision is healthful air that meets or exceeds air quality standards for all Valley residents. The District is a leader in air pollution control. Valley residents take pride in our collective efforts to [illegible] air quality.

The District's Core Values

PROTECTION OF PUBLIC HEALTH
The District shall continue to strive to protect the health of all Valley residents through efforts to meet health-based, state and federal ambient air quality standards, based on science and prioritized where possible using health-risk reduction strategies.

ACTIVE AND EFFECTIVE AIR POLLUTION CONTROL EFFORTS WITH MINIMAL DISRUPTION TO THE VALLEY'S ECONOMIC PROSPERITY
District staff shall work diligently to adopt and fully implement air pollution control measures, provide meaningful incentives for reducing emissions, and develop creative alternatives for achieving emissions reduction.

OUTSTANDING CUSTOMER SERVICE
District staff shall work to provide excellent customer service for stakeholders in activities including: rule and plan development; permitting and emissions inventory functions; compliance activities; financial and grant funding transactions; and responses to public complaints and inquiries.

INGENUITY AND INNOVATION
The District values ingenuity and innovation in meeting the challenges we face. Examples of this spirit of innovation include developing programs that provide new incentives for emissions reductions, and providing alternate compliance strategies that supplement traditional regulatory efforts and generate more emissions reductions than could otherwise be reasonably obtained.

ACCOUNTABILITY TO THE PUBLIC
The District serves, and is ultimately accountable to, the people of the Valley for the wise and appropriate use of public resources, and for accomplishing the District's mission with integrity and honesty.

OPEN AND TRANSPARENT PUBLIC PROCESSES
The District shall continue to provide meaningful opportunities for public input and be responsive to all public inquiries.

RECOGNITION OF THE UNIQUENESS OF THE SAN JOAQUIN VALLEY
The Valley's meteorology, topography and economy differ significantly from those in other jurisdictions. Although it is valuable to review and evaluate efforts of other agencies, we must consistently look for solutions that fully consider the Valley's unique needs.

CONTINUOUS IMPROVEMENT
The District works to continually improve its internal operations and processes, and strives to streamline District operations through optimally utilizing information technology and human resources.

EFFECTIVE AND EFFICIENT USE OF PUBLIC FUNDS
The District shall continually strive to efficiently use all resources and to minimize costs associated with District functions.

RESPECT FOR THE OPINIONS AND INTERESTS OF ALL VALLEY RESIDENTS
The District shall respect the interests and opinions of all Valley residents and fully consider these opinions, working collaboratively, in carrying out the District's mission.

Attaining Ozone Standard Marks a HISTORIC ACHIEVEMENT FOR THE VALLEY

For the first time in recorded history, the San Joaquin Valley in 2013 had zero violations of the hourly ozone standard established under the federal Clean Air Act, down from 281 violations in 1996. In 2004, EPA classified the Valley as "Extreme" non-attainment for this standard, meaning that reaching the standard, at that time, was deemed impossible. San Joaquin Valley is the first and only region in the nation with "Extreme" classification to attain the standard.

Reaching this milestone has been a key focus of the Valley's air quality-management strategies for more than two decades. Since 1992, the District has developed and implemented numerous attainment plans and adopted more than 500 of the most stringent rules in the nation to obtain the significant emission reductions needed to demonstrate attainment. Additionally, the District has supplemented its regulatory programs with a robust, voluntary incentive program, providing more than $500 million in incentive funds, resulting in a reduction of more than 100,000 tons of emissions.

Despite significant progress, in 2010 under federal law, Valley residents and businesses became subject to an annual $29 million penalty. At the time, the Air District crafted an alternative approach that kept these penalties from going to federal coffers. Under the alternative approach that was approved by EPA, the Valley was able to retain those dollars and invest them in the Valley's local economy to fund clean-air projects in the eight-county region.

WORKING TOGETHER

Attaining this key smog standard is a historic accomplishment that reaffirms the effectiveness of the investment and commitment by Valley businesses and residents to reduce emissions and improve public health. The members of the District's Governing Board were unanimous in their appreciation of the enormity of this achievement, and in expressing their gratitude to key stakeholders that made this achievement possible.

Valley businesses and farmers have been instrumental in helping to craft cost-effective strategies that routinely exceed mandates through their expert input and willingness to form an effective, result-oriented public-private partnership with the District. Billions of dollars have been invested to reduce emissions through the installation of newer/cleaner technology and the replacement of older, higher polluting equipment.

Valley residents consistently rank air quality as a top quality-of-life issue and have taken an active role in reducing air pollution. Public support and participation during Air Alert episodes in 2013 were critical to avoiding the few remaining 1-hour ozone violations.

Local, state and federal policy makers have provided necessary funding and support commensurate with the region's air quality needs. This success is the result of diligent work by local elected officials and community leaders and support from the California Partnership for the San Joaquin Valley.

With more than 80 percent of the Valley's emissions coming from mobile sources, ARB's efforts to reduce emissions from this sector have been crucial. EPA Region 9 has worked with the District to maneuver through the complicated mandates of the Clean Air Act and to bring resources to the Valley.

Valley environmental organizations have been successful in drawing attention to the Valley's air quality challenges and assisted the District in successfully advocating for the Valley's fair share of financial resources by initiating audits, which have highlighted the effectiveness and efficiency of the District's air quality management programs.

The District's Governing Board has to be commended for their great insight and skill in balancing the Valley's economic, meteorological, and topographical challenges. They have consistently devised and implemented entrepreneurial strategies that have effectively reduced air pollution while accommodating the Valley's unique needs. These innovative strategies now serve as a model for the rest of the nation.

NEXT STEPS

The District will now submit a formal request to the federal Environmental Protection Agency to declare the Valley in attainment and lift the $29 million penalty mandate.

The attainment test for the 1-hour ozone standard of 0.12 parts per million is based on the number of exceedance days per year, averaged over a three-year period. In other words, if an air monitoring site has three or fewer exceedance days in a three-year period, then it meets the standard. If a single site violates the standard, the entire San Joaquin Valley is then in violation of the 1-hour ozone standard.

The District's request for an attainment finding by EPA will include extensive technical support information. Special issues such as transboundary ozone from Asia, the District's ozone saturation study to address the Arvin monitoring station relocation, and an exceptional event whereby the Valley experienced an exceedance of the 1-hour ozone standard due to a large industrial fire and wildfires will also be addressed.

2013 CLEANEST YEAR ON RECORD

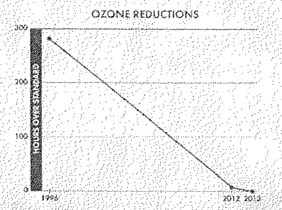
Despite strings of triple-digit temperatures and wildfires, 2013 was the cleanest year on record for Ozone.

1996 ▶ 281 hours over the standard

2012 ▶ 7 hours over the standard

2013 ▶ 0 hours over the standard

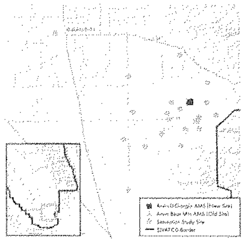
First region in nation to go from "Extreme" to "Attainment," due to the investment and sacrifice of Valley residents, businesses, farmers and dairy families.



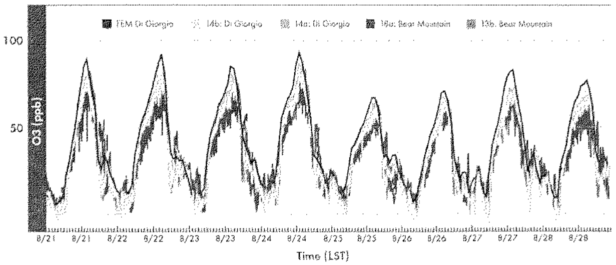
Arvin Ozone Saturation Study

To enhance public outreach and education, the District is working to develop online resources that will provide Valley residents access to additional air quality information and statistics customized to their neighborhood. The Arvin Ozone Saturation Study was funded by the District to establish scientific correlations enabling the District to estimate and report neighborhood-level ozone concentrations. The study was also designed to answer outstanding questions regarding an old ozone monitor in Arvin that was relocated by the state Air Resources Board in December of 2010. A replacement station was located by ARB at the Di Giorgio Elementary School in Arvin. Some individuals affiliated with environmental groups have argued that the Valley should not be allowed to claim attainment with the 1-hour ozone standard without returning the monitor to the old Arvin Bear Mountain location.

In summer 2013, 23 new solar-powered ozone samplers were deployed to 21 locations, with three co-located at official monitoring sites to continually ensure and verify accuracy of the samplers. Two monitors were located across the street from the old Bear Mountain site in Arvin. Ozone concentrations were measured continuously (24 hours per day) for six weeks beginning in mid-August until the end of September. The majority of the monitoring locations for this special study were clustered in and around the community of Arvin with a scattering of samplers farther from the community to examine ozone in the surrounding area. The extensive data collected here provides the scientific foundation for establishing ozone gradients for multiple locations in and around Arvin. This data indicates that ozone concentrations at the new Di Giorgio Elementary School site are actually higher than those measured at the old Bear Mountain site. Therefore, demonstrating attainment with existing monitors is actually more conservative and health-protective than the proposed alternative to reinstitute the old Arvin Bear Mountain site. Additionally, the new monitor measures ozone in close proximity to children at the elementary school, which provides for greater public health protection for this sensitive population.


Arvin-Di Giorgio AMS (New Site)
Arvin Bear Mtn AMS (Old Site)
Saturation Study Site
SJVAPCD Border

Hourly and One Minute Ozone



How much Ozone from Asia Travels into the Valley?

In 2013, the District funded the second phase of research by University of California, Davis scientists that employed a series of daily air flights to collect real-time ozone data in order to estimate the entrainment of transboundary ozone into the airspace of the southern San Joaquin Valley.

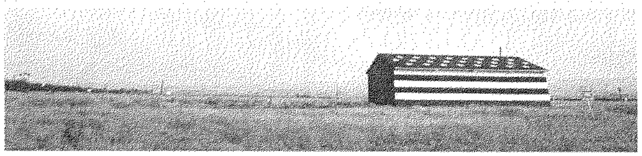
The first phase, which began in 2011, was designed to measure the long-range movement of ozone and fine particles (PM2.5) from Asia into the airspace of the San Joaquin Valley. Continuous ozone, PM2.5 and carbon monoxide data was gathered at the Chews Ridge monitoring station, located at 5,200 ft. in the Santa Lucia Mountains southeast of Monterey. Additional flight transect data was collected by monthly air fights within the San Joaquin Valley and from the Valley to the Pacific. The results show that approximately an average of 50 ppb of Ozone under summer conditions from offshore flows in the free troposphere above the marine boundary layer (above 4,500 ft).

In the second phase, ozone concentrations were measured continuously by 12 daytime flights on peak days in summer 2013. NW to SE flights, which transect down the Valley from Sacramento to Arvin area, were used to measure ozone mixing into atmospheric boundary layer. Additionally, same-day flights in the south Valley with Arvin focus were used to measure circulation and downward mixing.

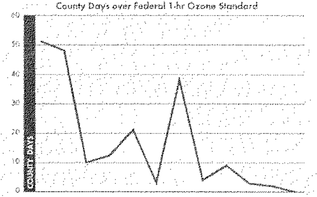
The data collected from the second phase will be used to evaluate the hypothesis that a significant fraction of ozone concentrations on peak days in the southern San Joaquin Valley is attributable to transboundary ozone. The results of this research will become increasingly important as the EPA is likely to further lower the federal 8-hour ozone standard in 2014, creating an even more difficult challenge for the Valley to achieve attainment.

As an emergent area of study in the research community, compelling findings on the impact of transboundary ozone on California air quality have been discovered. Recent research by the National Oceanic and Atmospheric Administration (NOAA) found evidence that transboundary ozone flow from Asia was significantly impacting ground-level ozone monitors in the northern Sacramento Valley. Additionally, daily flows of transboundary ozone were found to be highly correlated with ozone exceedance events in Butte County, CA. Regarding peer-reviewed estimates of transboundary impacts in the San Joaquin Valley, a 2013 publication based on NASA-funded field research has estimated that transboundary ozone flows are contributing up to 30 ppb to ground level concentrations which amounts to 12 percent to 23 percent impact in Bakersfield during periods of high spring and summer transport. While transboundary ozone impacts on any given day will depend on weather conditions, there is little question that transboundary ozone is making an incremental contribution to daily ozone concentrations in the Valley with a comparable impact on the number of 1-hour and 8-hour exceedances.

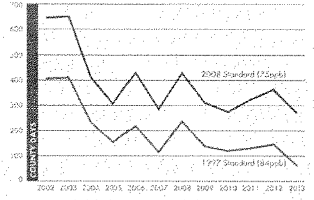
Through extensive investment and sacrifice by businesses and residents, the San Joaquin Valley has made tremendous progress in reducing ozone concentrations over the last several decades. As the Valley continues to decrease its levels of ozone, there is a growing concern that air quality impacts from transboundary ozone may jeopardize the region's ability to attain current and future federal ozone standards. Since transboundary ozone is primarily generated through fossil-fuel combustion in Asia and consequently carried across the Pacific Ocean towards the western United States, the District has no control over these emissions and is unable to address this issue through its local regulatory strategies.



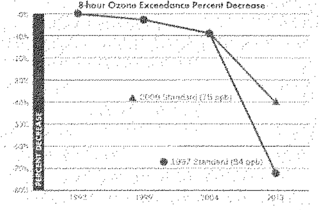
Ozone Trends


County Days over Federal 1-hr Ozone Standard

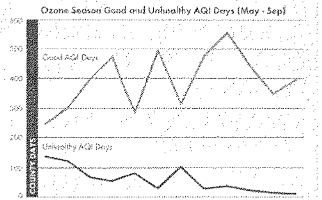
- The year 2013 made history by being the first year to ever record zero exceedances of the federal 1-hour ozone standard.


County Days over Federal 8-hr Ozone Standard

- Days over the federal 8-hour ozone standards continue to decline. 2013 had fewest exceedances of 1997 standard in Valley history.

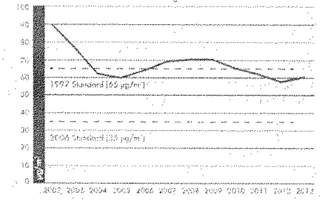

8-hour Ozone Exceedance Percent Decrease

- 40% decrease in days over 2008 8-hr ozone standard since 1992, and 72% decrease in days over the 1997 standard over the same time period.

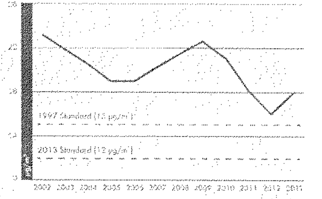

Ozone Season Good and Unhealthy AQI Days (May - Sep)

- Continued decrease in the number of Unhealthy AQI County-Days during the ozone season of May to September.

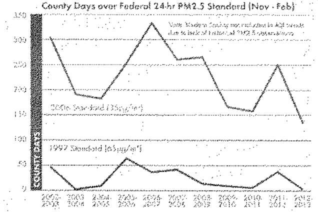
PM2.5 Trends


24-hour PM2.5 Design Value Trend

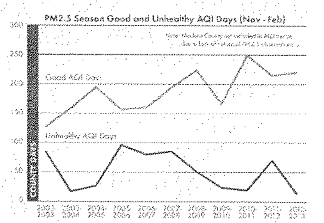
- The 24-hour Design Values remains below the 1992 federal standard.


Annual PM2.5 Design Value Trend

- The increase in PM2.5 Design Values is due to the extreme meteorological conditions at the end of 2013.


County Days over Federal 24-hr PM2.5 Standard (Nov - Feb)

- The downward trend continued during the wood burning season of 2012/13.


PM2.5 Season Good and Unhealthy AQI Days (Nov - Feb)

- The positive trends for both Good days and Unhealthy continued in the 2012/13 wood burning season.

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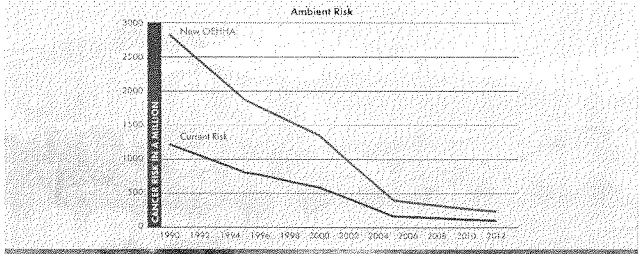
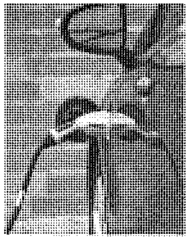
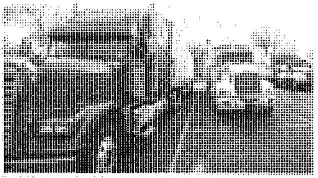
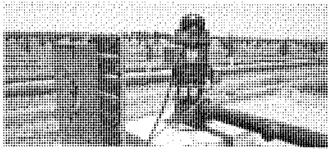




The District funded 391 **CLEAN AIR VEHICLES** with $1,025,498

More than **$17 MILLION** [illegible] 483 **HEAVY DUTY DIESEL TRUCKS**



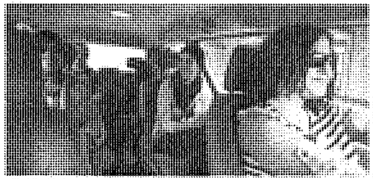


The District replaced 328 **AG PUMP ENGINES** with [illegible]

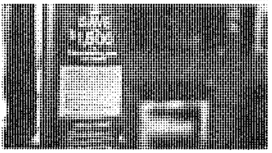
Continuing to Invest in our Valley

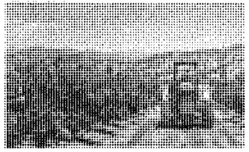
The largest area of growth at the Valley Air District is in its Grants and Incentives Program. In fewer than 10 years, awards through the District have increased more than tenfold, reflecting the ongoing commitment of the District, business and industry and Valley residents in making clean-air investments that will benefit all of us.

During 2013, more than **$103 MILLION** in District funding and private investment found its way to projects that reduced more than **9,000** tons of lifetime emissions in the Valley air basin.



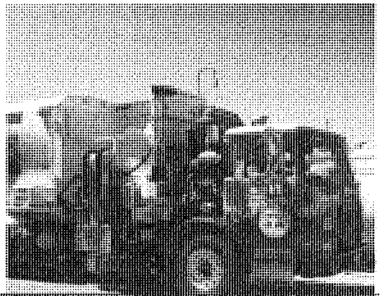
The District issued 29,221 **VANPOOL VOUCHERS** with $906,600

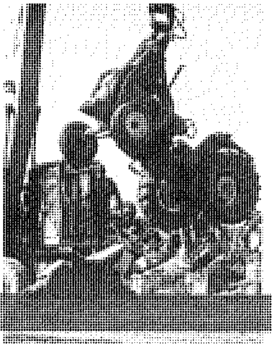


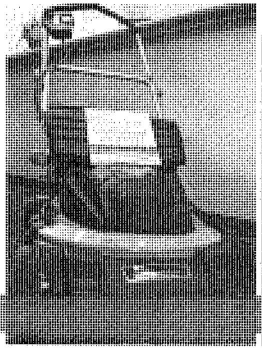


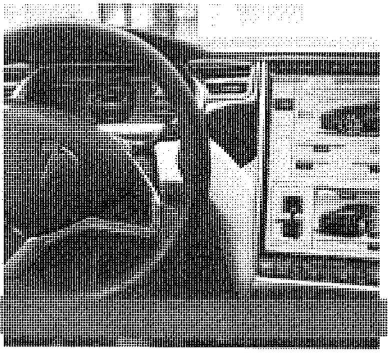
276 **TRACTORS** [illegible] $23 MILLION

The District funded 1,037 **NEW CERTIFIED STOVES & INSERTS** with $563,650









Grants

TECHNOLOGY ADVANCEMENT PROGRAM

The Technology Advancement Program's primary goal is to advance technology and accelerate the use of innovative, clean-air technologies that can reduce emissions as rapidly as practicable. Despite major reductions in emissions and concomitant improvements in air quality, the San Joaquin Valley continues to face difficult challenges in meeting federal air-quality standards. It is virtually impossible for the Valley to attain the new standards for ozone and particulates without significant advancements in low-emission technologies for mobile and stationary sources.

The Technology Advancement Program has opened three rounds of funding and received over 100 proposals for clean-technology projects. The District has committed to funding 16 of these projects totaling $5 million. In 2013, two projects were completed and final reports are now available on the program web page.

Technology development focusing on Valley needs can be enhanced through partnerships and collaborations with other air districts and state agencies. Additionally, strategies for reducing emissions in the Valley can benefit regional and state air quality. To make the most of these co-benefits, the District is participating with EPA Region 9, the state Air Resources Board, South Coast Air Quality Management District and other agencies in the Clean Air Technology Initiative (CATI), where these partners aim to use available resources through research and technology demonstration efforts.

District staff will continue to search for opportunities to support projects that build the air-quality technology research and demonstration capacity of colleges and universities in the Valley, improving the ability of local institutions to engage in future clean-technology projects that are specifically suited to the Valley's needs.

AG TRACTOR REPLACEMENT PROGRAM

In 2013, the District's Agricultural Tractor Replacement Program successfully replaced 776 old, high-polluting Tier 0 and Tier 1 Agricultural Tractors with new, cleaner Agricultural Tractors. The goal of the program is to provide an incentive equal to approximately 50 percent of the cost of the new equipment with the remaining cost share contributed by the farmers. As expected, the interest in the program remained extremely strong during 2013, with the District contributing over $32 million and the farmers contributing over $32 million. The 776 projects resulted in 5,114 tons of emissions being reduced over the lifetime of the projects.

During the course of the Ag Tractor Replacement Program, the District recognized that many small, Valley farmers have the oldest, highest polluting agricultural tractors but are financially unable to meet the program cost-share requirements. To address this issue, the District created and successfully implemented the first Tractor Trade-Up Program in the State of California. Instead of crushing a Tier 1 tractor that was turned into the program a small farmer is given the opportunity to take possession of the Tier 1 tractor and turn in their old Tier 0 tractor to be recycled. This program has the potential to remove hundreds of old high polluting agricultural tractors that would not have otherwise been recycled with zero financial burden to the small farmer.

LAWN EQUIPMENT

The highly popular, consumer-oriented Clean Green Yard Machines program helps San Joaquin Valley residents clean the air through rebates by replacing gas-powered mowers with nonpolluting, electric mowers. In 2013, 170 old gas-powered lawn mowers were replaced with cleaner electric models through this successful public program.

The Cordless Zero-Emission Commercial Lawn and Garden Equipment Demonstration Program successfully ended in June 2013 with a total of 4 technology demonstrators, 60 participants and 445 pieces of equipment for in-use testing. The program demonstrated the performance and durability of electric equipment in non-residential applications to accelerate market acceptance and build upon the progress already made in the residential sector.

ELECTRIC VEHICLE WORKSHOPS AND GRANTS

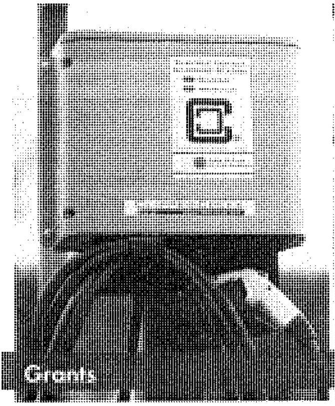
Reducing pollution from mobile sources will be challenging without the mass adoption of plug-in electric vehicles (PEV) throughout the region. Toward that end, the District is working to prepare the Valley for PEVs by developing plans for electric vehicle charging stations, as well as incentive programs to offset the costs of both vehicles and infrastructure.

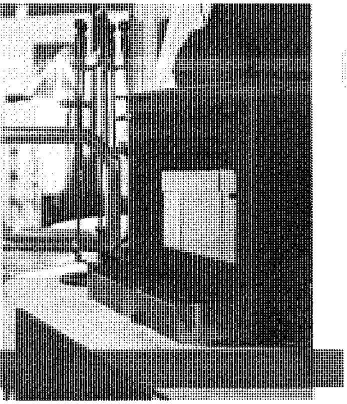
The Department of Energy awarded $75,000 to the District as part of the California PEV Readiness Project, a statewide, multi-agency collaboration. During this one-year project, the District worked with other agencies and created a statewide, community-based PEV readiness assessment. The Statewide and Regional San Joaquin Valley PEV Assessment was released in January 2013 and included an extensive assessment of the Valley region.

Based on recommendations in the PEV Assessment, and to help coordinate and address the concerns specific to our Valley, a regional PEV Coordinating Council (PEVCC) was established. This 28-member advisory group is comprised of local Metropolitan Planning Organizations, Cities, Counties, Energy Utilities, the local Clean Cities Coalition, Electric Vehicle Service Providers, as well as local consultants and Non-Profit Organizations. The Air District was also awarded $200,000 from the California Energy Commission to build upon the Statewide and Regional San Joaquin Valley PEV Assessment and develop a more comprehensive PEV Readiness Plan specifically for the Valley.

In addition, the District began to conduct PEV education and outreach, share recommendations and best practices with Valley stakeholders and residents, and help implement as many recommendations as possible.

The District also supported the growth of PEVs in the Valley via the Drive Clean rebate program. This program provided a rebate (up to $3,000) to assist 391 Valley residents in purchasing a PEV.





Grants

PUBLIC BENEFIT GRANTS PROGRAM

Approved by the Governing Board in 2011, the Public Benefit Grants Program funds a wide variety of clean-air, public benefit projects that will directly benefit Valley residents. Eligible applicants are public agencies and public educational institutions within the geographical boundaries of the San Joaquin Valley air basin. The program has three components: New Alternative-Fuel Vehicle Purchase, Advanced Transit and Transportation, and Alternative Fuel Infrastructure. To date, the District has received 166 applications for more than $10 million in requested funds for the New Alternative-Fuel Vehicle Purchase component. The Advanced Transit and Transportation component was released to competitive bids and 15 proposals were awarded more than $5 million in funding. The third component for Alternative Fuel Infrastructure received 17 project proposals with nearly $16.5 million in funding requested.

BURN CLEANER

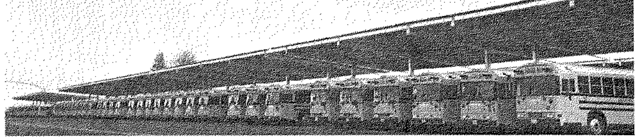
The Burn Cleaner woodstove change-out program provides incentives to San Joaquin Valley residents to help reduce emissions by replacing older, more polluting wood burning devices with cleaner gas devices, clean-burning pellet devices or cleaner-burning EPA Phase II-certified wood burning devices. To date, the District has received more than 3,500 applications and provided more than $2.1 million in funding since the program began.

[illegible]

[illegible]

District Administers School Bus Program for Other California Air Districts

The primary goal of the Lower-Emission School Bus Program (LESBP) is to reduce schoolchildren exposure to both cancer-causing and smog-forming pollution. In addition to administering the program in the San Joaquin Valley, the Air District administers the program for 18 other local air districts throughout the state of California. To date, the Air District has expended more than $25 million through this program to retrofit 444 school buses and replace 150 high-emitting school buses in these other 18 air districts. Based upon the success of the Air District's administration of the Lower Emission School Bus Program the California Air Resources Board (ARB) requested the assistance of the Air District to administer the statewide school bus retrofit program for 34 air districts in the State of California. During fiscal year 2012-2013, the Valley Air District retrofitted 41 school buses and expended $800,000. The District's implementation of this program has proven successful, and ARB has asked the District to continue running this program on their behalf through 2016.



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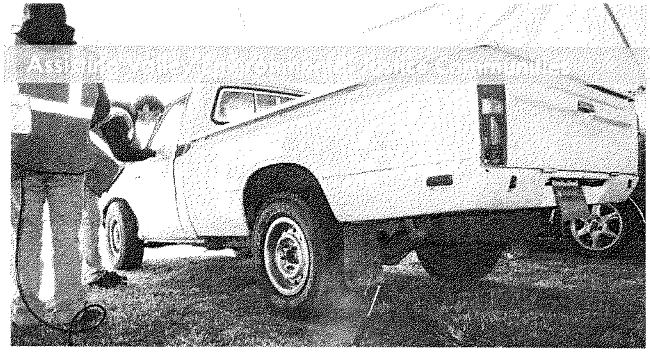


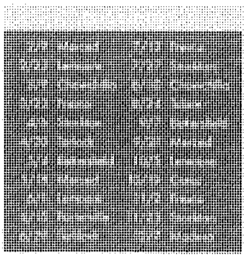
The District has a history of working to ensure that residents in every corner of the Valley have access to the cleanest air possible, innovative grant opportunities and targeted communication to keep informed of District action.

Tune In, Tune Up

In 2013, the District continued its award-winning Tune In, Tune Up program, providing an additional $4 million in funding and hosting 22 events throughout the San Joaquin Valley.

Tune In, Tune Up is designed to identify and repair high-emitting vehicles. The Tune In, Tune Up program is operated in partnership with Valley Clean Air Now, which has a long history of successfully implementing this program and excels at reaching residents in environmental justice communities who otherwise may not be able to afford costly vehicle repairs. Reaching this key demographic is essential as the emission reductions are most needed in low-income communities, which are historically home to the greatest percentage of high-emitting vehicles.

Through weekend events, participating residents have their vehicles screened to determine if they qualify for emissions-related repairs at little to no cost to them. In the Tune In, Tune Up program, vehicle owners bring their vehicles to one of the program's weekend events, where an emissions test is performed to determine the likelihood of that vehicle failing the required biennial smog test. Owners of vehicles that fail this initial screening are provided with vouchers that are redeemable at participating smog shops for up to $650 in emissions-related repairs plus the cost of smog checks and diagnostic time. Once the vehicle is repaired, confirmatory smog tests are conducted that can then be used for vehicle re-registration purposes. In 2013, more than 5,000 vouchers were issued to Valley residents through these weekend events.



Environmental Justice Advisory Group

In 2007, the District adopted the Environmental Justice Strategy. One of the new initiatives of the Strategy was the formation of an advisory group, Environmental Justice Advisory Group. Since its formation five years ago the members continue to work diligently with District staff to provide guidance and input on a variety of key issues. Notably, EJAG members have provided great input on the various District incentive programs, including the Burn Cleaner woodstove change-out and truck grant programs. The EJAG also serves as a forum to gather public input and enhance public participation.

Since its formation the group had been meeting monthly, but recently decided to meet every other month. On the month that they meet, it is on the fourth Thursday at 5:30 p.m. A complete list of the new meeting dates and more information on the District's Environmental Justice Strategy and EJAG can be found at: http://www.valleyair.org/Programs/EnvironmentalJustice/Environmental_Justice_idx.htm.

Enhanced Public Outreach for Permitting

In 2013, to expand the public's opportunities to take part in and comment on proposed permits, the District implemented several enhancements to its public outreach processes for permitting projects. Federal, state and local regulations require the District to post public notices of proposed permitting projects in local newspapers, but the District has also posted notices on its website (www.valleyair.org) for many years. Since early 2013, however, we have greatly enhanced this service by also posting all public permitting notices in Spanish, and by allowing people to sign up to receive notices by mail or by email. Such notices can now be requested for any permitting project requiring public notice for a specific facility in the Valley, for all permitting projects in a region of the Valley, or for all permitting projects in the entire Valley, and can be received in Spanish language or English language versions. The District provides in-house oral translation services to interested parties, often provided by District employees familiar with the permitting project and its potential air quality impacts.

To further enhance these public outreach services, the District has improved the District's Public Notice web page by improving search capability and the page's layout to make projects easier to find. To streamline requests for facility-specific information and maximize outreach while minimizing the District resources required, a new feature has been incorporated into the District's internal Permit Administration System to track and maintain these requests, and automatically generate the requested notices.

The District's state-leading public outreach efforts have been recognized by and presented to other air districts in the state, and are encouraging other agencies to look for ways to improve public outreach in meaningful ways, while also demonstrating that such efforts, if carefully planned and automated, are not necessarily resource-intense.

District Offers Assistance to Truckers

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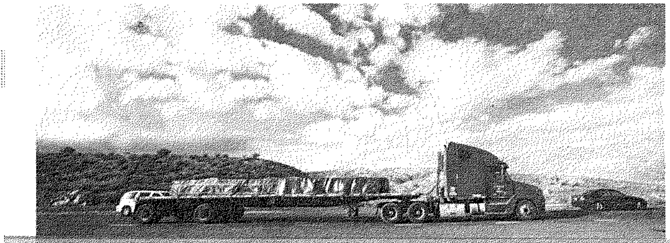


Local Concerns with the State's Truck Regulation

More Action is Needed to Avoid Economic Devastation to Valley Truckers and their Customers
The state's truck and bus regulation was adopted in 2008 to reduce particulate matter and NOx from existing diesel vehicles operating in California. In 2010, the state Air Resources Board amended the rule to provide some relief and an extension in light of the economic recession. Under this rule, most heavier trucks were required to have a particulate filter in place beginning January 1, 2012 and older trucks are required to be replaced starting January 1, 2015. In the meantime, owner/operators of small fleets became subject to a January 1, 2014 deadline to install particulate filters.

The District is extremely concerned that a large number of these small independent owner/operators were unable to comply with the requirement to install a filter by January 1, 2014. These truckers cite financial hardship and operational difficulties with filters working properly as reasons for their inability to comply. For many of the owner/operators, the retrofit cost ($15,000 - $20,000) exceeds the value of the truck, therefore rendering this option infeasible. Due to the economic downturn and limited access to credit, many owner/operators are not able to finance retrofits or replacements. Additionally, State delays in Proposition 1B funding due to California's fiscal crisis have reduced previous access to these funds for many fleets.

The District estimates that there are approximately 20,000 small fleet trucks registered in the San Joaquin Valley, with a high percentage of those being single owner-operators operating in rural and environmental justice communities (up to 15,000 trucks).

At the urging of the District and other stakeholders, late in 2013 the Air Resources Board granted a short extension until mid-2014 for truckers demonstrating "good faith" efforts to comply. Although this provides some needed relief, the District is concerned that more strategic action is required to achieve the needed reductions in truck emissions while minimizing adverse economic impacts. Towards that end, the District has allocated an additional $10 million in incentive funding to assist truckers in replacing their vehicles. The District is also offering additional recommendations to the state Air Resources Board for increased flexibility and resources to achieve the necessary reductions in emissions in a balanced fashion. These recommendations include:

- Providing more flexibility in grant eligibility requirements for truckers,
- Extending upcoming deadlines for filter installation in exchange for earlier replacement and conversion to a cleaner 2010 model truck,
- Allowing an extension for trucks that can demonstrate extreme economic hardship,
- Allowing an extension for low-use and vocational-use trucks,
- Allowing trade-up to a cleaner model in lieu of a 2010 model for some truckers (owner/operators of small fleets), and
- Providing more state funding for truck replacements.

It is also important to note that the January 1, 2014 deadline was the first of several critical deadlines, and thousands of additional trucks will become subject to additional requirements in the coming years. Early and comprehensive action is imperative to avoid future crises as we approach these difficult deadlines.

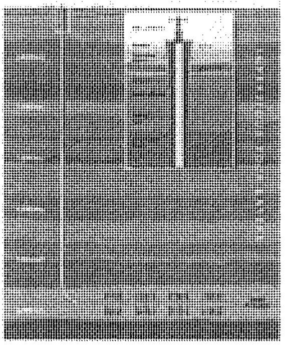
District addresses
Hydraulic Fracturing in the San Joaquin Valley

Significantly increased hydraulic fracturing in the oil production industry is possible in the near future in the San Joaquin Valley. The Valley Air District regulates air emissions from oil production operations, including those associated with hydraulic fracturing, and ensures that all associated permitted oil production equipment is well-controlled and regularly inspected. However, given the potential increase in hydraulic fracturing, and an intense public interest in the subject, the District will be maintaining a strong presence in new regulatory and industry efforts associated with hydraulic fracturing.

Hydraulic fracturing has been occurring in oil production operations of the southern San Joaquin Valley for at least three decades, with approximately 500 wells hydraulically fractured per year. Hydraulic fracturing, or "fracking," is a method to enhance the recovery of oil or natural gas from the rock layer in which the oil or gas resides, known as the producing formation. A production well is drilled through the various strata and lined with several layers of steel casing and cement. In a non-fractured well, the producing formation is sufficiently porous to allow the oil or gas to flow freely into the well. With hydraulic fracturing, "fracturing fluids" or "pumping fluids" consisting primarily of water and sand with small amounts of other chemicals, are injected under high pressure into the producing formation. This creates fissures that allow the oil or gas to move more freely from rock pores where it is trapped. The water and other fluids are extracted from the fissures, but the sand "proppant" stays behind, propping the fissures open so that the oil or gas can flow freely.

With recent discoveries relating to the Monterey Shale formation, we may see a significant increase in oil production along with associated hydraulic fracturing activities in the Valley. Recent reports of estimates of the oil contained in the Monterey Shale have concluded that it contains more than 15 billion barrels of oil (more than 80 percent of which is in the Valley), it may meet more than 60 percent of the U.S. consumption needs, and could result in the creation of tens of thousands of jobs and billions of dollars in revenues in the San Joaquin Valley.

Groundwater Protection through Proper Well Construction



The drilling and operation of oil and gas wells is regulated by the Division of Oil, Gas and Geothermal Resources (DOGGR), part of the California Department of Conservation. DOGGR has the overall responsibility to ensure that well drilling and operations are carried in a manner to protect the environment, prevent pollution, and ensure public safety. According to preliminary DOGGR assessments, hydraulic fracturing in California has historically not created negative environmental impacts.

However, widely reported environmental problems with fracking associated with natural gas production in Eastern and Midwestern states have grabbed the public's attention. Water contamination has been the most frequently expressed public concern with respect to hydraulic fracturing, but a number of other potential environmental concerns have been raised, including potential climate change and air quality impacts. There are important and significant differences in the natural gas hydraulic fracturing in eastern states, often covered by the nation media, and the oil well fracking that has been occurring in the San Joaquin Valley. For instance, the oil reserves in the Monterey Shale are at an average of 11,000 feet below the surface, and are capped by a significant layer of less permeable "cap rock." This cap rock has trapped the oil and gas for millennia and keeps these petroleum reservoirs isolated from the water table and earth's surface. In California, hydraulic fracturing is principally a means of ensuring that individual, conventional wells attain maximum production, often, according to DOGGR, a preferable alternative to drilling additional wells to produce the same resources.

In some other parts of the United States, such as the Marcellus Shale gas deposits in New York, Pennsylvania, Ohio, Maryland, Virginia and West Virginia, natural gas is trapped not in a reservoir protected by cap rock, but inside uncapped rock formations much closer to the earth's surface and the water table. In these "unconventional" cases, hydraulic fracturing is necessary to free the resource for production, but doing so in the absence of a rock cap introduces a risk of fracturing the producing formation to such an extent that the surface or water table is compromised.

According to DOGGR, there are other differences between the typical use of hydraulic fracturing in California and elsewhere. For instance, in other states the extraction of unconventional natural gas resources requires lengthy fracturing periods along long stretches of horizontally-drilled production wells. Millions of gallons of water are injected under constant pressure, a process that may take days or weeks in order to effectively open the reservoir rock. In California, much less water is used and the period of pressurizing the reservoir rock is much shorter.

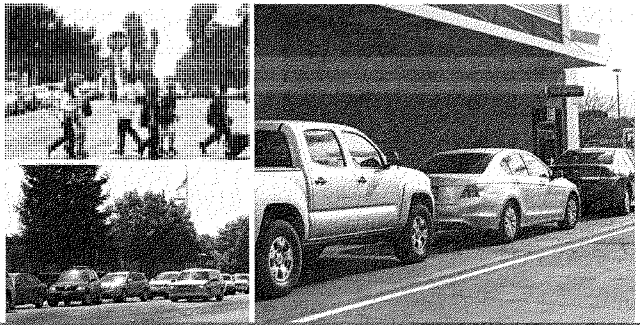
Finally, most oil production in the San Joaquin Valley is relatively isolated from human habitation, while in more populous areas of the nation, production wells exist in backyards and high school football fields.

While other potential environmental impacts may deserve attention, the Air District's focus has naturally been on air quality impacts. There are a number of potential sources of emissions of various pollutants, including emissions from diesel engines that are associated with oil well drilling and fracturing operations, the storage and handling of fluids used in the hydraulic fracturing process and the resulting produced fluids, and fugitive dust emissions from sand handling, and from travel on unpaved roads and work areas. Hydraulic fracturing fluids contain small amounts of chemicals, some of which are known volatile organic compounds and air toxic compounds. These chemicals make up less than one percent of the fluids used in hydraulic fracturing, with the water and sand comprising more than 99 percent of the total materials injected.

While the District believes that emission sources from equipment used in hydraulically fractured wells are currently adequately regulated, given the potential for significant increase in hydraulic fracturing and heightened level of public attention and concern, it is appropriate to fully evaluate the overall air quality impact from hydraulic fracturing operations and to ensure that regulatory efforts address any potential air quality concerns.

Until recently, there were no specific laws or regulations in California pertaining to the process of hydraulically fracturing wells. In early 2013 DOGGR began a rulemaking process to impose new requirements for well stimulation, including hydraulic fracturing. Subsequently, California Senate Bill 4 (SB4) – Oil and Gas Well Stimulation was signed into law in September 2013. SB4 requires DOGGR to establish interim regulations by Jan 1, 2014, study the environmental impacts of well stimulation, including air quality impacts in 2014, and approve final regulations by Jan 1, 2015.

Consistent with the District's belief that duplicative and overlapping regulatory efforts are symptomatic of bad government, any additional regulations regarding hydraulic fracturing would be most effectively promulgated by DOGGR on a state-wide basis. District staff is committed to working cooperatively with DOGGR, the oil production industry, and other interested parties to provide technical support during studies of air quality impacts of hydraulic fracturing and will strongly advocate that DOGGRs new regulations provide the appropriate protection of air quality. Only if DOGGR fails to protect air quality in the San Joaquin Valley will the District step in and develop appropriate and necessary regulations.



Vehicle Idling

Emissions from vehicle idling presents a significant air-quality problem in the San Joaquin Valley. The Air District has embarked on an aggressive public outreach campaign to stem these noxious pollutants.

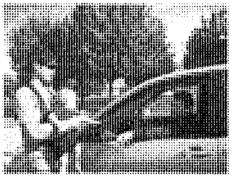
Vehicle idling is especially prevalent during school-time traffic in mornings and afternoons, and in the use of drive-through services. In fact, vehicle idling has been shown to be a major contributor to late-summer ozone pollution in August and September.

Statistics also show that 43 percent of the students who are driven to school in private vehicles live within one mile of the campus. These vehicles linger by the curb with engines running while dropping off students, producing high levels of nitrogen oxides, particulates and volatile organic gases, all of which contribute to ozone and particulate pollution. Idling a vehicle for merely four minutes produces emissions equivalent to driving for one mile, and idling a vehicle for just 10 seconds consumes more fuel than "cutting" and restarting the engine.

The District, in conjunction with its Healthy Air Living Schools program, has created and distributes, free of charge, "no idling" signage that is displayed by many Valley schools. The "no-idling" message has also been incorporated into literature and training for school-based programs.

Instead of idling a vehicle, the District recommends:

- Organizing carpools so that fewer vehicles are being driven on a daily basis
- Avoiding the use of drive-through services
- Taking alternate transportation or walking a child to school
- Refraining from idling whenever possible



Wood Burning Assessment in Foothill Communities

The District's current residential wood burning Rule 4901 provides an exemption for burning in communities without access to natural gas. This exemption was provided in consideration for economic and other feasibility issues associated with non-wood burning alternatives in these communities. Additionally, the primary purpose of the current rule was to achieve PM2.5 attainment in urban areas where the Valley's peak PM2.5 concentrations occur.

Most District communities in the higher elevations of Madera, Fresno, and Tulare Counties are not served by natural gas (e.g. Oakhurst-Coarsegold, Shaver Lake, and Three Rivers). Some foothill communities, however, are equipped with natural gas service, and are thus subject to Rule 4901 requirements. For example, the Greater Frazier Park area has access to natural gas, and the District has devised a separate forecast area for them given the cleaner air levels in the area with respect to the rest of Kern County. There is anecdotal evidence that certain foothill communities in the Valley experience high wood smoke episodes during the winter season. Consistent with the District's Health Risk Reduction Strategy, the Governing Board approved a field study to assess wood smoke concentrations in the air in nearby foothill communities in order to minimize localized particulate pollution from wood burning.

While the atmospheric conditions in foothill communities are generally more favorable to pollutant dispersion as compared to the Valley floor, localized adverse health impacts are possible. The District will conduct field inspections to identify the extent and the source of wood smoke within these communities. Foothill and mountain communities such as Shaver Lake and Oakhurst are small enough geographically to effectively and efficiently deploy inspectors to conduct surveillance during this wood burning season. Additionally, the data collected through the field surveys will be utilized to conduct dispersion modeling to quantify potential wood smoke concentrations and identify the geographic areas impacted by sources of wood smoke in these communities.

At the conclusion of this evaluation, if the District finds that residential wood smoke is a public health issue in these foothill communities, staff would bring a recommended course of action for addressing this issue through a voluntary "Please Don't Light Tonight" outreach program in these communities. Through this voluntary strategy, residents would be encouraged to voluntarily curtail wood burning during these forecasted episodes and offer incentives to upgrade old, higher polluting wood burning devices with EPA-certified fireplace inserts and stoves. Additionally, the District would also engage in efforts to educate foothill residents about the health hazards of wood smoke and identify the most effective methods for notifying residents when the voluntary curtailment strategy is in effect.

Online Complaint Reporting

As an enhancement to the District's already robust complaint response program, air pollution problems can now be reported to the District using a new online complaint reporting system at www.valleyair.org/complaints.

The District's new online reporting system is easy to use. Once in the system, users are prompted to enter relevant information about the problem, such as the type of problem (odor, smoke, dust, etc.), a description of the problem, and date, time and location it occurred. There is also an option for users to attach a picture or video to the complaint. The system will also allow users to automatically receive an electronic copy of the investigation report via email.

The new online complaint system adds to the many existing ways the public can report air quality problems to the District. In addition to the new online system, the public can also report complaints on one of the District's three toll-free hotlines, the bilingual (Spanish-English) telephone complaint line or use the District's iPhone app for smoking vehicle complaints.

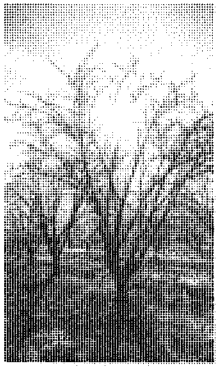
All complaints received are referred to a District inspector for follow-up and handling. Public complaints are often the initial indicator of air quality issues in a community. As such, the District places the highest priority on responding to air pollution complaints and operates an on-call program to ensure timely response to complaints, even during non-business hours.

Formerly Known as the Risk-Based Strategy

In 2013, the District's Risk-Based Strategy was renamed as the Health-Risk Reduction Strategy. This change was made to more simply and forcefully describe the overarching goal of the strategy which is prioritizing public health.

The Risk-Based Strategy is aimed at giving top priority to reducing health risk rather than the singular focus on reducing the mass of emissions, which has been the conventional approach under the federal Clean Air Act. This was done in recognition of the fact that health benefits or risk are not always proportional to the mass of pollutant emissions. This new strategy relies on sound science, which indicates that differences in toxicity, particle size, precursor potency and actual exposure are the key drivers that must be understood in devising strategies that can best reduce public health risk. Therefore, this approach can better be described as the District's Health-Risk Reduction Strategy. This strategy is now the guiding principle by which the District develops and executes plans, regulations and incentive-based strategies to attain health-based air-quality standards in the quickest, most health-protective and cost-effective manner.

In response to rapidly expanding body of scientific research, the risk-based approach is also gaining support from both U.S. EPA and the scientific community. In fact, in their proposed implimentation rule for the 8-hour ozone standard, EPA incorporates a number of proposals suggested by the District under the Health-Risk Reduction Strategy. Industry representatives have largely embraced the strategy even though it targets certain sources for new air pollution control strategies. This is largely due to the fact that the Health-Risk Reduction Strategy provides an assurance of effective controls that produce real air quality benefits as opposed to the "shotgun approach" under the conventional mass-based strategy.



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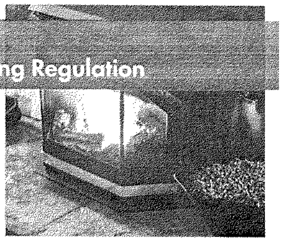
The District adopted the "Fast Track" action plan to pursue non-regulatory measures to assist the Valley in accelerating attainment of the federal ozone standard. One component of the "Fast Track" plan is to pursue energy efficiency and air quality friendly changes at local businesses.

The District has partnered with the Greater Stockton Chamber of Commerce to share their award winning "Green Team San Joaquin" model with other communities around the San Joaquin Valley. The program is designed to address environmental and economic development issues as it relates to the cost of doing business. A main component of the program is conducting on-site business assessments designed to reduce energy consumption, waste, and air pollution while improving the bottom line for businesses. With funding from the District the Stockton Chamber has met with over 20 communities around the Valley. As a result of these efforts, a number of "Green Teams" have been established around the Valley.

District Takes Early Steps to Improve Residential Wood Burning Regulation

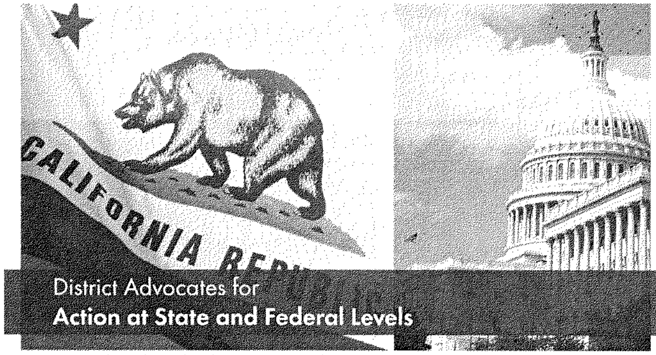


In December 2012, the Governing Board adopted the 2012 PM 2.5 Plan and accelerated the process for lowering the threshold for daily residential wood burning prohibitions during winter seasons. This measure will assist the Valley in further reducing PM2.5 emissions during the critical winter season, with additional resulting health benefits. A critical component of this new strategy includes allowing residents that have invested in cleaner burning devices to burn during certain wood burning prohibitions, and increasing incentives for clean wood burning devices provided through the District's Burn Cleaner incentive program.

In anticipation of amending the District's pioneering Residential Wood burning Rule (Rule 4901) in mid-2014, the District began working with stakeholders and gathering information to better inform the amendment process. The District held five meetings with Valley hearth retailers to begin discussions regarding potential rule amendments and enhancements to the Burn Cleaner woodstove change-out incentive program. After receiving valuable input from the retailers, the District re-launched the grant program in October and provided retailers with in-store signage and materials. The stakeholder meetings also provided important on-the-ground information which will be used to help craft the upcoming rule amendments.

In addition, the Governing Board approved a bilingual telephone survey to be performed in early 2014 to assess the wood burning habits of Valley residents. Although the survey will include questions related to driving habits and lawn care, the main focus of the survey is wood burning. The survey will include urban, suburban and rural households with both cellular telephones and land lines.

The District plans to begin a robust public process in early 2014 to communicate the results of the survey and gather comments on the proposed changes to the rule. Upon approval by the Governing Board, the District will communicate any rule changes in preparation for the 2014-15 winter PM season.



District Advocates for Action at State and Federal Levels

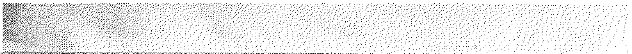
The District continues to partner with Valley stakeholders and elected officials to advocate for state and federal policies and resources that will assist the Valley in meeting its air quality objectives.

At the state level, this past year, significant effort was put into developing a broad-based coalition that was successful in advocating for the re-authorization of the funding for the Carl Moyer and AB 118 incentive programs. These funding programs are critical to the continued reduction of mobile source emissions and for the development of advanced technologies that will allow for reductions into the future.

At the federal level, the District continued to advocate, through Congress and the EPA, for legislative and policy changes to address outdated provisions of the Clean Air Act. These efforts have been productive, as EPA included many of the District's suggestions in their proposed implementation rule for the 8-hour Ozone Standard which was recently published for public comments.

In the coming year, the District will continue to advocate on air quality issues that impact the Valley. Some of the priority issues include:

FEDERAL	Seek common sense improvements to the Federal Clean Air Act
STATE/FEDERAL	Advocate for additional resources for mobile source reductions
FEDERAL	Seek continued air quality funding in the farm bill
STATE	Seek revenue from the Cap and Trade program
STATE/FEDERAL	Seek additional resources for air quality monitoring instruments
FEDERAL	Continued push for air quality empowerment zone legislation
STATE/FEDERAL	Pursue energy efficiency and alternative energy measures
STATE/FEDERAL	Support for adequate resources/policies to reduce the air quality impact of wildfires
STATE	Support California Environmental Quality Act (CEQA) reforms that will streamline the process

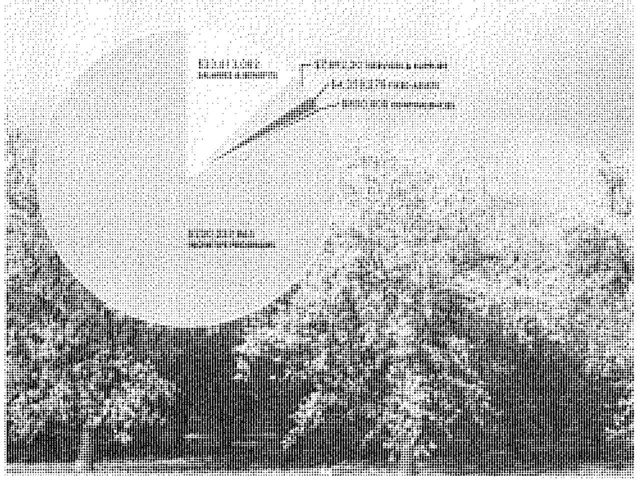


Overview of THE DISTRICT'S OPERATIONS

Codified in the Air District's Core Values, accountability is one of the most important aspects of all of the District's operations, goals and strategies. Our organization is accountable to the public for every dollar spent and every regulation adopted. We're accountable for demonstrating quantifiable progress toward clean air. And we're accountable for conducting our day-to-day business in the most effective, efficient and innovative ways possible.

Our track record demonstrates these values. We're given the highest marks by auditors and other agencies. We consistently set a high bar for air-quality improvements that other air management agencies emulate. And we also set the gold standard for customer service.

We offer you the following operational information about how the District is cleaning the air, saving money and implementing continuous improvement [illegible] undertakings, continuing the tradition [illegible] have come to expect.



Streamlining and Efficiency

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ONLINE FACILITY PORTAL

The District released the initial test-version of the Online Facility Portal to a small group of permitted facility operators in 2013. These operators are now able to access all permitting information associated with their facilities, from up-to-date status of pending permit applications to historical permitting documents. The Facility Portal concept was approved by the Board during the 2013 Board Study Session and is intended to give easier, quicker access to permit holders for viewing and submitting information. When fully developed, in addition to 24-7 access to permit information, the system will also provide finance information, online bill payment, electronic report submittal, and electronic application filing capabilities.

RENTAL IRRIGATION ENGINES

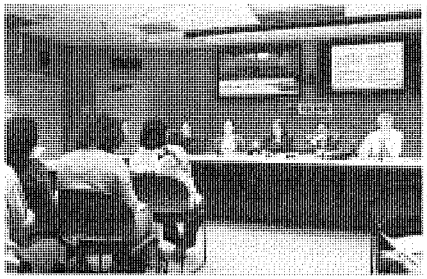
The District, working with the Valley's agriculture industry, has developed an innovative permitting approach that allows rental agricultural irrigation engines to be replaced on a seasonal basis with as-clean or cleaner engines without first having to obtain a modified permit. Permit modifications must be sought within seven days after such a "routine replacement" – a timeline that allows the fast-paced agricultural industry unparalleled permitting flexibility while also continuing to improve air quality by reducing emissions from the irrigation engine fleet.

AGGREGATE PROCESSING

The District worked with the aggregate processing industry to develop first-of-its-kind streamlined permitting procedures for fast-track processing of permits for new construction and infrastructure improvement projects at aggregate processing facilities. The expedited processing of these projects will contribute to the recently seen economic recovery in the Valley, while simultaneously providing improved air quality through reduced reliance on diesel internal combustion engines at these facilities.

IMPLEMENTATION OF DISTRICT RULE 2410 – PREVENTION OF SIGNIFICANT DETERIORATION

During 2013, the District developed various streamlining tools to enable the District to implement its new Prevention of Significant Deterioration (PSD) permit processing role at a much quicker pace than previously experienced by applicants under EPA's program. PSD is a preconstruction permitting program for new and modifying major sources of attainment pollutants, and is required by the federal Clean Air Act (CAA). Historically PSD permitting projects within the Valley were evaluated by the US EPA, in a process that often took over two years to complete, drastically impacting Valley businesses' ability to expand. The District has been able to use these permit streamlining tools to reduce the PSD permitting timeline to four to six months.



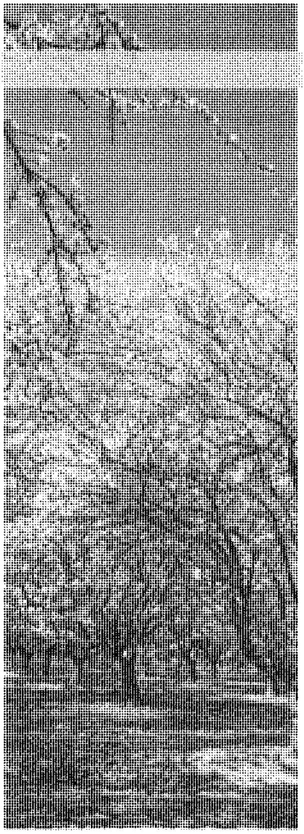
ELECTRONIC PERMITTING AUTOMATION
The District continues to enhance automation of an interdepartmental communication system called the "change order" process that the District uses to pass permitting information from the Compliance Department to the Permit Services Department. With the successful launch of this electronic tool, during 2013 the District was able to significantly decrease the time it takes to convert an Authority to Construct permit to a Permit to Operate and reduce the number of pending conversions. Enhancements to the change order automation are expected to be fully implemented in 2014.

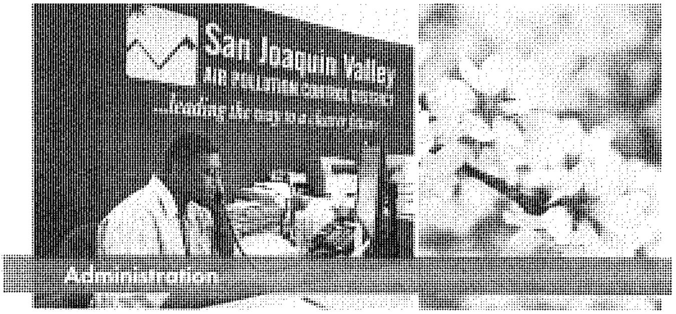
METHANE EMISSIONS FROM LANDFILLS
In 2010, the California Air Resources Board (CARB) adopted a regulation designed to reduce methane from the state's landfills. While the state anticipated implementing this regulation on its own, the District, after consulting with the Valley's landfill operators, has entered into a memorandum of understanding with CARB to implement and enforce the rule on a local level. District implementation and enforcement of these requirements, as opposed to state implementation, will result in a better use of government funds as the District already regulated landfills under its air quality permitting programs, and will provide a higher level of service to the Valley's regulated landfills.

AIR MONITORING AUTOMATION, REMOTE CONNECTION AND MODERNIZATION
A modernization project to enhance air-quality monitoring automation is in final stages of the testing phase. When fully implemented, the new systems will reduce travel, equipment maintenance and data review time.

REDUCING FIELD STAFF TRAVEL TIME WITH INCREASED ACCOUNTABILITY
Global Positioning System (GPS) units have been installed in all field staff vehicles to increase inspector safety, efficiency and accountability, allowing staff to be deployed quickly and efficiently to respond to unforeseen events such as public complaints and equipment breakdowns at facilities.

NEW TECHNOLOGIES IN INSPECTION PROGRAMS
Compliance inspection staff has been equipped with tablet computers, which allow them to complete inspection report forms while in the field; reduce time associated with paperwork; increase field time; and allow additional inspections to accommodate workload increases.




San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT
...leading the way to a clean future

Administration

Administration is comprised of the Executive Management staff and several divisions that provide support services for the District's core operations. For budgeting purposes, these functions are structured under: General Administration, District Counsel, Personnel, Administrative Services, Information Technology Services and Outreach and Communications.

GENERAL ADMINISTRATION
The General Administration Division is responsible for the overall management of the District. Under policy direction of the Governing Board, the Executive Director/APCO and the Deputy APCO represent the Board's interests, and oversee the development and implementation of policies and procedures, formulation of policy alternatives and recommendations, overall management of personnel and resources, and development and implementation of air quality-related programs. Also included in General Administration is the Senior Policy Advisor, who supports the APCO in advocacy efforts advancing Board-adopted legislative priorities and positions.

DISTRICT COUNSEL
The District Counsel is the chief legal advisor to the Governing Board, the Executive Director/APCO, the three District Hearing Boards, and the San Joaquin Valley-wide Air Pollution Study Agency. Under policy direction of the Governing Board, the District Counsel provides legal representation and advice in both litigation and general law matters.

PERSONNEL
The Personnel Division performs the full range of personnel support activities for all departments. Specific program activities include: recruitment, classification and pay, records management, legal compliance, labor relations, training and management/supervisory support. In addition, the Division is responsible for minimizing risk to the District through employee benefits, workers' compensation and wellness programs.

The Personnel Division has also taken a lead role in the development and implementation of the STAR (Service, Teamwork, Attitude, Respect) work culture program and both internal and external Healthy Air Living program activities.

ADMINISTRATIVE SERVICES
The Administrative Services Division is responsible for all fiscal and general services related functions of the District, oversight of the District clerical staff, records management, and oversight of the Clerk of the Boards function. The fiscal functions include preparation and control of the District's budget; responsibility for accounting and auditing all District revenues and expenditures; preparation of financial statements and related reports and incentive grant financial management, including state and federal grant reporting. The general service functions include: responsibility for facilities management, fleet maintenance, purchasing and risk management.

Rules & Regulations

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GASOLINE TRANSFER INTO STATIONARY STORAGE CONTAINERS, DELIVERY VESSELS, AND BULK PLANTS (RULE 4621)

Amended in December, language in Rule 4621 was updated to make it consistent with ARB testing standards. The amendments removed ARB certification requirements for the aviation gasoline bulk loading operations and required these operations to be equipped with a vapor recovery system that would meet a minimum volumetric control of 90 percent. Amendments also included other minor corrections and removed redundant or expired language. These amendments to Rule 4621 were administrative clarifications that do not result in a detrimental impact on air quality.

GASOLINE TRANSFER INTO MOTOR VEHICLE FUEL TANKS (RULE 4622)

Amended in December, amendments to Rule 4622 incorporated an exemption from requiring Phase II vapor recovery systems for E85 (85 percent ethanol and 15 percent gasoline) fuel dispensing facilities based on EPA and ARB guidance that Phase II is not required for E85 fueling. Amendments also incorporated requirements consistent with ARB's guidance for certified Phase II vapor recovery systems and reduced the frequency of the Dynamic Back-Pressure Test from once every 12 months to once every 5 years, which is consistent with EPA's guidance on minimum test frequencies. This amendment will reduce the resulting emissions inherent from performing the test. The District also incorporated other minor revisions and removed redundant or expired language. These amendments to Rule 4622 were administrative clarifications that do not result in a detrimental impact on air quality.

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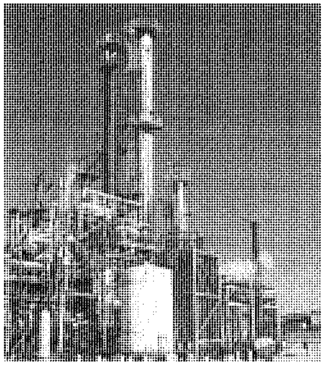

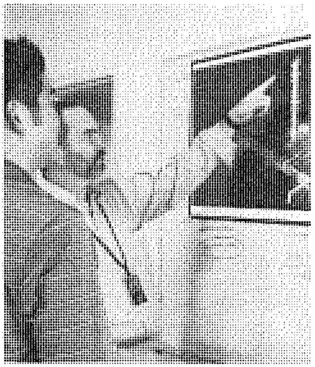

INDIRECT SOURCE REVIEW (ISR)
Indirect sources are buildings or facilities, such as new residential housing and shopping center developments that attract mobile sources of emissions, but may not directly emit pollution. The District's ISR group analyzes applications to assess the potential indirect emissions created by a development project, quantifies the mitigation proposed by the applicant, and may assess a development mitigation fee if insufficient mitigation is proposed by the applicant. An annual report of ISR activity, and the emission reductions generated by the program, is published by the District each year.

EMPLOYER BASED TRIP REDUCTION (ETRIP)
Rule 9410, Employer-based Trip Reduction, requires employers with more than 100 eligible employees at a single location to submit and implement plans designed to encourage carpooling and other trip-reduction efforts by employees. The District has developed an easy-to-use online eTrip Plan submittal and reporting program, saving significant time for both eligible employers and the District. www.valleyair.org/Programs/Rule9410TripReduction/eTRIP_main.htm

SMALL BUSINESS ASSISTANCE (SBA)
The District operates an effective SBA program to provide assistance to help stakeholders who lack the resources or expertise needed to efficiently obtain air permits. District SBA engineers provide expert advice on technology options, application processes and any other air quality issues. Interested parties can contact the District SBA through hotline telephone numbers in any region of the Valley.

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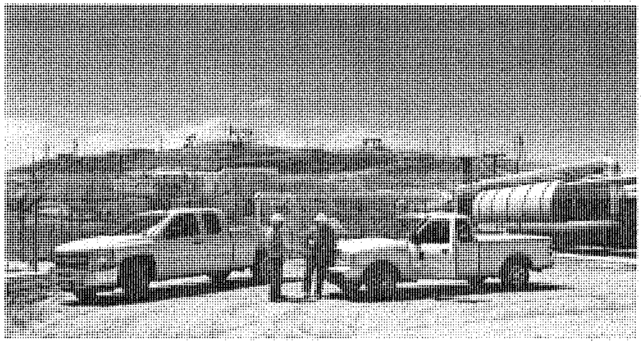
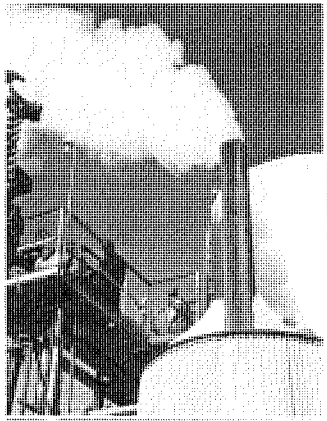
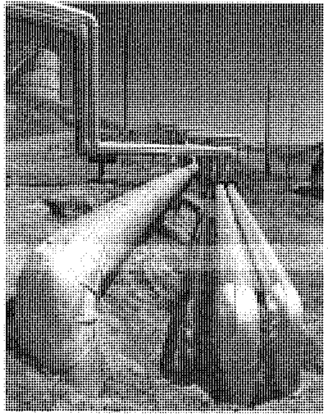
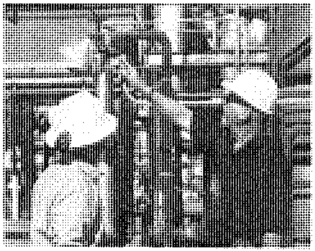
Enforcement









ENFORCEMENT ACTIONS

When violations of rules and regulations are discovered, the District delivers an appropriate level of enforcement action to ensure an expeditious return to compliance, and assesses monetary penalties to deter future violations. Disputed cases are generally handled in-house and settled through a mutual settlement process. On the rare occasion that a case cannot be settled through the mutual settlement process, the case may be transferred to District Counsel for more formal action. In 2013, the District processed nearly 2,100 issued notices, transferred 115 cases to District Counsel, and collected approximately $3.8 million in settlements.

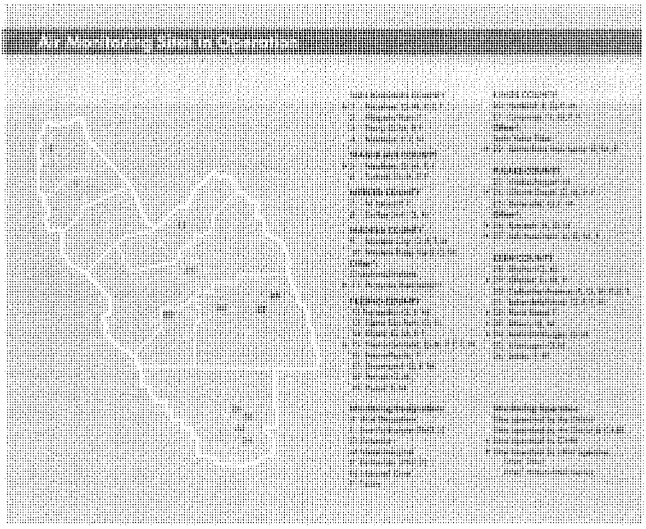
HEARING BOARDS

The Hearing Boards are quasi-judicial panels that act independently of the District. They are authorized by state law to provide temporary relief from District rules and regulations if strict conditions prescribed under the California Health and Safety Code are met. Any excess emissions associated with the temporary relief granted by the Hearing Boards represent only a very small fraction of the Valley's total emission inventory and cannot, by law, be likely to interfere with the attainment and maintenance of health-based air quality standards or cause a public nuisance. In 2013, 124 variance petitions were heard at 52 hearings.

AIR MONITORING

The Valley Air District operates an extensive network of air quality monitors to support its mission of improving air quality and protecting public health. The District uses hourly readings from its real-time monitors to generate a daily Air Quality Index (AQI) forecast for each Valley county. The AQI communicates the state of air quality to Valley residents so they can keep air quality in mind as the plan their activities. The District also rigorously analyzes collected air quality data to help chart the future path to ozone and PM2.5 attainment.

Leveraging recent advancements in technology, the District will continue to expand the use of automated monitoring equipment and remote connection systems to allow for remote diagnostics and monitoring equipment repairs. This results in increased efficiency and reduced travel to distant monitoring stations. The District has added, or is in the process of adding, several new monitoring stations to its network to address federal requirements, to improve modeling and forecasting analyses, and to provide additional air quality information to Valley residents. The District is also in the process of installing four new near-roadway air monitoring stations in response to new federal mandates. These stations will be located in Fresno, Bakersfield, Modesto and Stockton.



Legal Activities

DISTRICT PREVAILS IN CHALLENGE TO ITS PERMITTING RULES DESIGNED TO ELIMINATE DUAL PERMITTING REQUIREMENTS

This was a challenge to EPA's approval of District Rule 2410, enabling the District to assume from EPA administration of the permitting program for Prevention of Significant Deterioration. Petitioners sought to return permitting authority to EPA, with the potential for imposing cumbersome and inefficient dual permitting requirements on regulated facilities. This suit was successfully resolved on October 8, 2013, when Petitioners dismissed their Petition following the filing of the District's brief.

DISTRICT DEFENDS ITS RULES EXEMPTING MINOR AG SOURCES FROM PERMITTING

In September 2013, an environmental group filed a petition in the Ninth Circuit Court of Appeal to challenge EPA's approval of District rules clarifying that "minor" agricultural sources are exempt from the District's offset authority. The District has intervened in order to defend the validity of its rules. Briefs will be due in early 2014.

DISTRICT AWAITING ORAL ARGUMENT IN CHALLENGES TO OZONE, PM 2.5 PLANS

These two, similar cases involve a challenge to EPA's approval of the District's 2008 PM2.5 Plan and the District's 2007 8-Hour Ozone Plan. The challenges focus almost entirely on CARB's "State Strategy" portion of the Plan. In order to protect the region's interests, the District intervened to defend the entirety of the plans, including those adopted exclusively by CARB. The case is fully briefed and awaiting oral argument.

ENVIRONMENTAL GROUPS CHALLENGE THE DISTRICT'S METHOD OF COLLECTING NONATTAINMENT PENALTIES

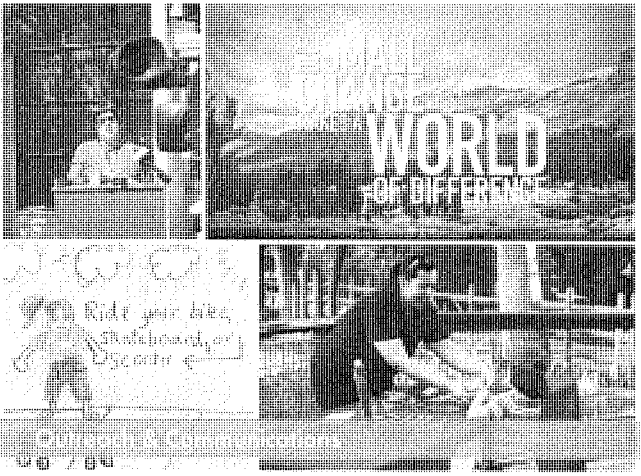
This suit involves a challenge to EPA's recent approval of District Rule 3170, which the District adopted in May 2011 to implement section 185 "nonattainment penalties" required by the Clean Air Act for the District's failure to timely meet the 1-hour ozone standard. The District moved to intervene in the case to defend its method of implementing section 185 penalties. This case has been fully briefed and is awaiting oral argument.

Information Technology

The District strives to use technology to provide the highest level of customer service and to be an example of efficiency. The District investment in technology paid dividends over the past year increasing efficiency and saving money.

PAPERLESS AGENDA CONSORTIUM (PAC)
Over the past year, the District established and sponsored the PAC in order to provide a forum for interested government agencies in the San Joaquin Valley to share paperless agenda resources, ideas, solutions, and technical knowledge. The PAC has a vision to facilitate efficient and cost-effective implementation of paperless agenda systems, enabling members of governing bodies to use common mobile devices for multiple agency agendas. The PAC now has over 50 members and includes representatives from all eight counties and many of the 59 cities in the San Joaquin Valley. The PAC has a good mix of members with technical backgrounds and government operations experience.

REDUCING COMPUTER FACILITY ENVIRONMENTAL IMPACT
In order to reduce the environmental impact of District computer facilities, the District set out to decrease electrical power, air conditioning and computer hardware requirements for its computer rooms. This effort has resulted in a reduction of 45 computer servers, which represents over 50 percent of the District's total. In addition, the server reduction allowed the District to avoid an air conditioning system upgrade that was estimated to cost over $100,000. This project proves that it is possible to save money while doing something good for our environment.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Outreach & Communications

In 2013, the District's Outreach and Communications team both embraced new challenges and disseminated historic good news about the air basin's never-before-achieved attainment of the federal 1-hour ozone health standard.

The team, a highly skilled group of communications professionals with expertise in public relations, media, graphics, web design and audio-video production, plays a critical role in providing bilingual information about current and expected air quality, grants programs, and educational and public information campaigns and programs, through a vital traditional and social-media outreach program.

This past year, the team elevated its presence on Facebook and Twitter, growing the number of followers and ensuring more people than ever before have access to important air-quality messaging. The team also ramped up its video production activities and continued to see increased participation in the District's Real-Time Air Advisory Network subscription program. The recently launched free iPhone app also continued to gather increased interest.

NEWS EVENTS
The historic attainment of the 1-hour ozone standard generated an exceptional amount of public and media attention. News conferences in all three regions announced the accomplishment in November.
New partnerships and funding into the consumer Clean Green Yard Machines electric lawn mower trade-in program were the topics of news conferences in all regions during summer. The program is the most popular consumer incentive program in the District's history.

Outreach & Communications

AIR ALERTS

A single Air Alert was called in September and regional news conferences ensured that Valley residents got the message. And, judging by the subsequent announcement of 1-hour ozone attainment, it appears they did.

CHECK BEFORE YOU BURN

After a relatively slow start to the Check Before You Burn wood burning curtailment season in November, air quality took a challenging turn in December, resulting in a string of back-to-back, Valley-wide curtailments. The outreach team fielded many calls from residents seeking information and from media focused on the statewide story of unusually warm temperatures and stagnant atmospheric conditions.

BURN CLEANER

The Burn Cleaner wood stove change-out program received a boost from additional funding and renewed commitments from the District's hearth retailer partners, resulting in more generous incentive amounts, increased funding to the much-needed low-income component, and a noticeable increase in applications for assistance from Valley residents in their purchases of cleaner wood burning devices, all of which directly benefitted winter air quality.

AIR QUALITY FLAG PROGRAM

The popular school-based program for educating and informing the Valley's students and school staffs continued its trajectory of increased participation. With a new partner on board – the Central California Asthma Collaborative – the flag program continued to receive a high number of enrollment requests.

REAL-TIME AIR ADVISORY NETWORK (RAAN)

Interest remained strong for enrollment in this important, free tool that keeps Valley residents informed of current, localized air quality. Available since 2012 through a free iPhone app, RAAN shows no sign of diminishing in its popularity or impact.

"BLUE SKY, BROWN SKY ... IT'S UP TO YOU!"

This free air-quality curriculum is sought after in both schools and by Valley parents and caregivers through a continued partnership with Valley Public Television. The colorful, educational curriculum is available in two grade levels tailored for elementary-school students.

HEALTHY AIR LIVING KIDS CALENDAR

The most-anticipated project of the year, the Kids Calendar, was produced in-house for the second consecutive year and the District quickly depleted its supply of 20,000 calendars. Distributed throughout the Valley to health care organizations, nonprofits, schools and individuals, the Kids Calendar continues to set the standard for engaging the Valley's children in an ongoing air-quality discussion.

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YARD MACHINES
www.valleyair.org/lawnmowers
SAVE $250!
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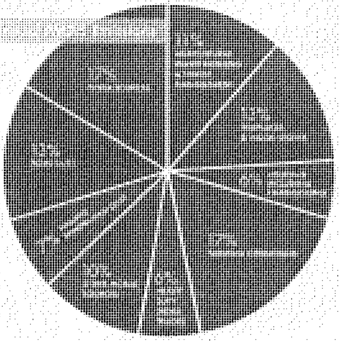
With these free healthy air living tools!
RAAN
Real-Time Air Advisory Network
AIR QUALITY FLAGS
Air Quality Flag Program
CALL for ENTRIES!
Students must submit artwork by Oct. 6, 2014!

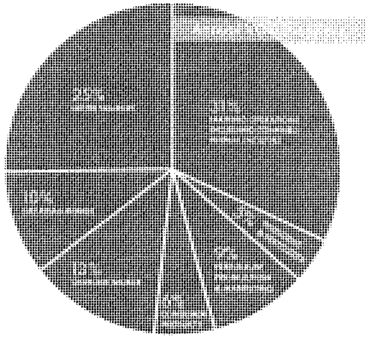
SOURCES OF POLLUTION

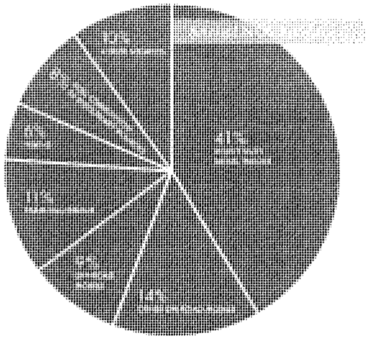
Despite major improvements in air quality, the Valley still faces significant challenges in meeting the federal, health-based, 8-hour ozone and particulate matter standards. These challenges are the result of the Valley's unique geography, topography and climate, which create ideal conditions for forming and trapping air pollution.

Ozone is the major component of the Valley's summertime "smog," and it affects human health and vegetation. Ozone is not emitted directly into the air, but is created by photochemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Particulate matter (PM) consists of tiny particles of solids or liquids (except pure water) that are suspended in the atmosphere. Particulate matter includes PM2.5 (particles less than 2.5 micrometers in diameter) and PM10 (particles less than 10 micrometers in diameter). PM can be emitted directly (primary PM, such as dust or soot), and can form in the atmosphere through photochemical reactions or gaseous precursors (secondary PM). Much of the Valley's ambient PM10 and PM2.5 is secondary PM, formed in atmospheric reactions of NOx.

In the San Joaquin Valley, due to our climate and the chemical composition of air pollutants, NOx is the primary culprit in the formation of both ozone and PM2.5. More detailed information on emissions is provided in the District's air quality plans, available at www.valleyair.org.







District Employees Give Back to the Community

In 2013, nine nonprofit organizations benefited from District staff's time, energy and resources in the third year of District-sanctioned community service.

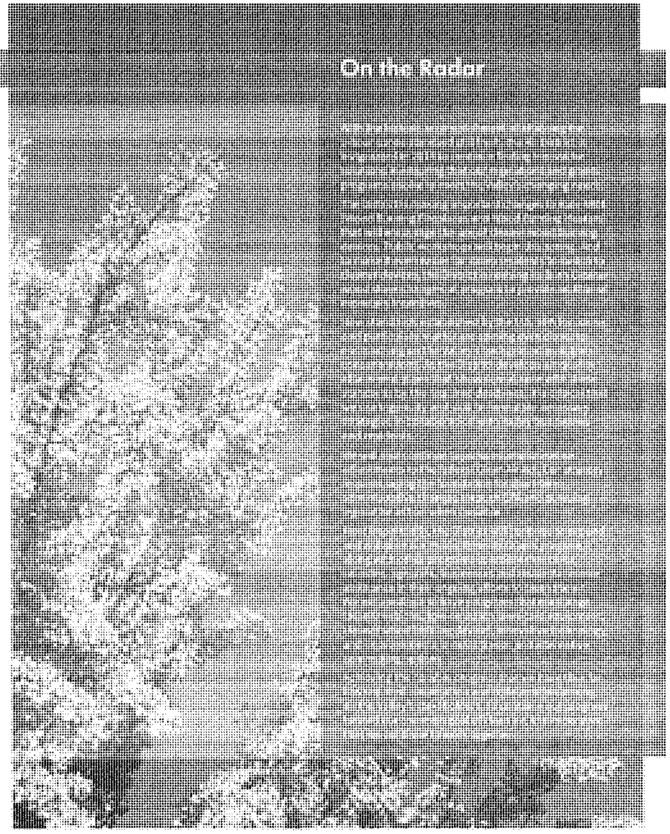
Each year, District staff selects its own projects, and coordinates and organizes activities. These projects demonstrate the many ways that District employees contribute not only to the betterment and health of their communities during working hours, but during their own free time, as well.

In the southern region, a tri-tip feast in September generated financial assistance for the Bakersfield Homeless Shelter, as well as gathered clean, gently used clothing, diapers and non-perishable food items for the shelter. In November, a lunch raised money and items for the Miriam Jamison Children's Center. And staff literally gave of themselves in a blood drive for the Houchin Community Blood Bank.

In Modesto, northern region staff gave of their sweat to build a home for a family selected by Habitat for Humanity and their blood in a drive for Delta Blood Bank.

In the central region, staff selected three organizations: Fresno's Bringing Broken Neighborhoods Back to Life, a broad coalition of community and civic groups; Rescue the Children, a transitional living environment for formerly displaced women and their children; and the Central California Blood Center. A Thanksgiving lunch hosted by the region's Information Technology section and attended by about 80 employees exceeded the donation goal of collecting 244 household items and toys valued at about $3,500. All three regions donated items.

Staff participation is voluntary and activities take place during non-working hours. Organizations are nominated by regional staff.



On the Radar

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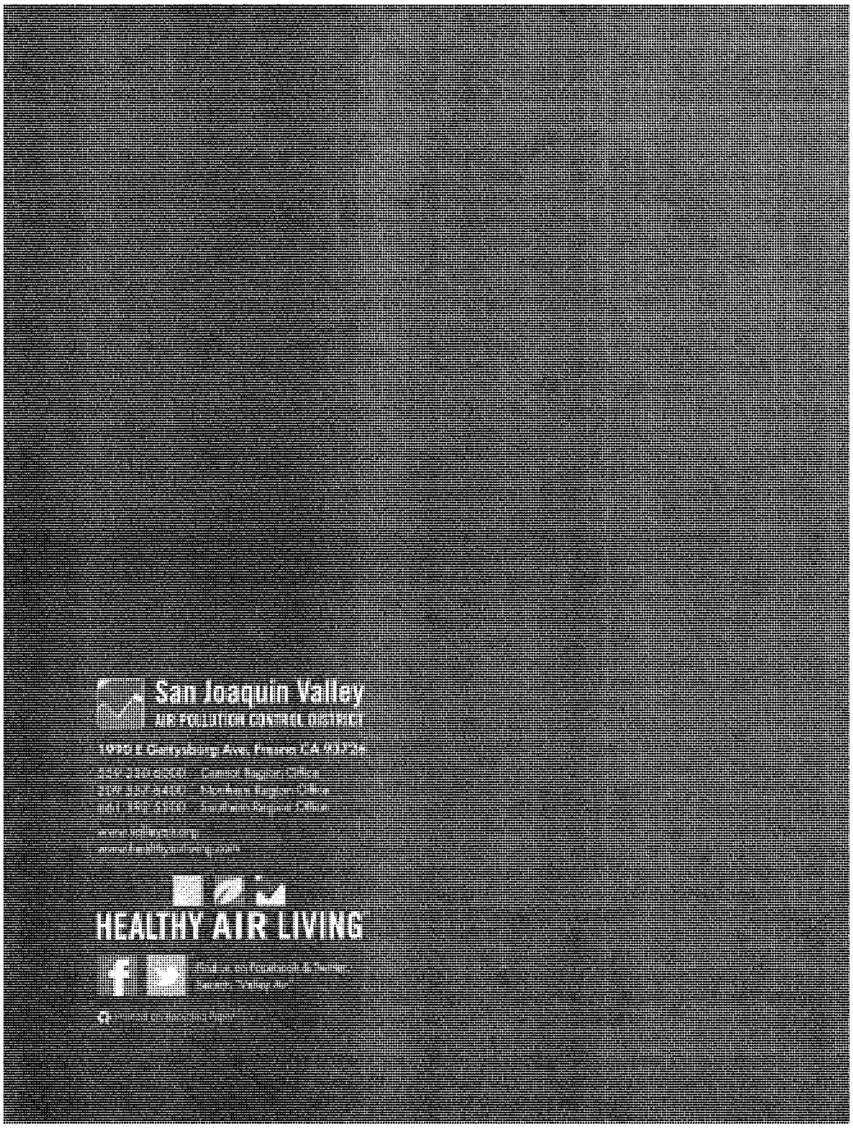

San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

1990 E Gettysburg Ave, Fresno CA 93726
559 230 6000 Central Region Office
209 557 6400 Northern Region Office
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AIR POLLUTION CONTROL DISTRICT

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Seyed Sadredin
Executive Director
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Northern Region Office
4800 Enterprise Way
Modesto, CA 95356-8718
(209) 557-6400 • FAX (209) 557-6475

Central Region Office
1990 East Gettysburg Avenue
Fresno, CA 93726-0244
(559) 230-6000 • FAX (559) 230-6061

Southern Region Office
34946 Flyover Court
Bakersfield, CA 93308-9725
(661) 392-5500 • FAX (661) 392-5585

www.valleyair.org

DATE: January 22, 2015

TO: SJVUAPCD Governing Board

FROM: Seyed Sadredin, Executive Director/APCO
Project Coordinator: Tom Jordan

RE: **ITEM NUMBER 10: APPROVE THE DISTRICT'S 2015 LEGISLATIVE PLATFORM AND TAKE POSITIONS ON ANTICIPATED FEDERAL AIR QUALITY LEGISLATIVE PROPOSALS**

RECOMMENDATION:

Approve the District's 2015 Legislative Platform and take positions on federal air quality legislation.

BACKGROUND:

At the beginning of each year, your Board adopts the District's legislative platform that will guide the District's legislative advocacy efforts. The policy positions outlined in the legislative platform will provide guidance on legislative and regulatory actions, and reflect current priorities involving air quality issues in the San Joaquin Valley. Upon adoption by your Board, the District staff will follow up by meeting with the members of the legislature to distribute the platform and to update them on the Valley's air quality challenges and needs.

The platform contains summary information about the District and air quality in the San Joaquin Valley, the District's top legislative priorities for the upcoming legislative session, and general principles that will guide the District when taking positions on specific legislative and regulatory proposals. During the past few years, the District has made a concerted effort to inform legislators at both the state and federal level of the air quality challenges that we face, past efforts to reduce air pollution, and the need for additional resources and policy tools to continue to bring cleaner air to Valley residents.

LEGISLATIVE PRIORITIES:

A summary of the District's 2015 legislative priorities are as follows:

- (Federal) Seek legislative common sense improvements to the Federal Clean Air Act. In addition to our legislative proposals, the District has worked with EPA to advance administrative changes that can address certain issues with the Clean Air Act. These efforts have been productive, as EPA included many of the District's suggestions in their proposed implementation rule for the latest 8-hour Ozone Standard.

- (State) The District receives State Subvention Funding to offset the costs of state mandated air quality programs. Despite significant increases in responsibilities and the impact of inflation, the funding level has not been adjusted for over 20 years. The District currently receives $900,000 per year which is less than 2% of the District's operating budget. The District supports an increase in State Subvention Funding.

- (State) As the state develops updated policies/guidelines for the Carl Moyer program, the District will pursue policies that continue to focus the program on public health, maintain formulas that take air quality challenges into consideration, and that utilize cost-effectiveness surplus emission reductions as the primary eligibility criteria.

- (State) The compliance regiment under the state's Cap and Trade program may lead to increases in criteria and toxic emissions or missed opportunities to reduce such emissions in certain areas. Therefore, the District will advocate for policies that target a portion of Cap and Trade revenues to regions that are already overly impacted by criteria pollutant emissions with a greater focus on environmental justice communities.

- (State/Federal) The District will oppose greenhouse gas measures that are detrimental to public health due to increases in criteria pollutant or toxic emissions, and support greenhouse gas measures that achieve criteria pollutant and toxic emissions reductions.

- (State/Federal) When assessing state/federal policies concerning disadvantaged communities, the District considers poverty as a key factor contributing to diminished public health. The District will oppose efforts that lead to "redlining" these communities and inhibit economic growth. The District will support measures that improve quality of life and economic welfare by providing new state and federal resources. The District will oppose measures that dilute local control by diverting local revenues or the authority over the expenditure of local resources to the state or federal government.

- (State/Federal) Seek funding and other support from the State Air Resources Board and federal Environmental Protection Agency (EPA) to install and operate additional air quality monitoring instruments throughout San Joaquin Valley.

- (State/Federal) Support efforts that provide for cost-effective alternatives to agricultural open burning, level the playing field and provide fair competition between biomass plants and other renewable sources of power, and additional research and development of alternatives to agricultural open burning.

- (State/Federal) Support state and federal funding of technology advancement projects to help develop technologies to meet federal air quality standards. Potential areas for funding include zero and near-zero emission mobile source projects, renewable energy projects, and projects to eliminate emissions associated with waste disposal.

- (State/Federal) Support adequate resources and policies to reduce the impact of wildfires and their attendant public health impact.

The final section of the Legislative Platform provides general principles that will guide the District when taking positions on legislative proposals that will impact the District or the ability of the District to achieve its goals. The general principles have been updated to be consistent with the current goals of the District.

DISTRICT POSITIONS ON ANTICIPATED FEDERAL LEGISLATION:

The above legislative priorities and the attached Legislative Platform will guide the District's positions on legislative actions throughout the year. However, the District anticipates a flurry of actions with the new Congress relating to the Federal Clean Air Act that warrant more explicit guidance from your Board. Furthermore, it is expected that Congress will attempt to guide clean air policies by influencing EPA actions through its agency oversight and budgetary authorities. A key focus of these efforts is expected to be actions relating to EPA's ability to set new air quality standards and to provide more congressional guidance relating to EPA's definition and treatment of exceptional events.

Consideration of Cost and Feasibility: The current language in the Federal Clean Air Act is silent on the need for EPA to consider cost or feasibility when establishing new air quality standards. Therefore, the Supreme Court has ruled that EPA cannot consider cost or feasibility when establishing health standards.

Provide More Time for the Establishment of New Standards: Currently, the Clean Air Act requires that EPA review and update air quality standards every five years based upon the latest health information. New standards, with new requirements and deadlines, are established even if significant parts of the country are still striving to meet existing standards.

Exceptional Events: Under current EPA policy the extreme drought conditions experienced in 2013/14 in the San Joaquin Valley and other regions in California are not eligible to be declared "exceptional events" since stagnation and lack of precipitation are not considered eligible events.

The following bills related to the above are expected to be re-introduced in the coming Congress:

CASE Act: The Clean Air Strong Economies (CASE) Act by Congressman Olson, Texas (Attachment B). The CASE Act requires that EPA not propose a national primary or secondary ambient air quality standard for ozone that is lower than the existing standard until at least 85 percent of the counties that were nonattainment areas under that standard achieve full compliance with the standard. Additionally, the CASE Act would require that EPA take into consideration feasibility and cost when setting standards and include in the regulatory impact analysis for the proposed and final rule at least one analysis that does not include any calculation of benefits resulting from reducing emissions of any pollutant other than ozone.

ORDEAL Act: The Ozone Regulatory Delay and Extension of Assessment Length (ORDEAL) Act by Senator Jeff Flake, Arizona and Congressman Matt Salmon, Arizona (Attachment C). The ORDEAL Act would lengthen the period between when EPA would review and set a new ozone standard from the current five year interval to ten years.

State and local air agencies are mandated to develop measures to meet federal ambient air quality standards that were set without considering the economic costs. The Act also sets attainment deadlines and implementation milestones that do not fully take into account natural environment (climate, geography, topography), magnitude of the needed emission reductions, availability of technology (maturity of existing control program, time needed to develop new technologies), economic feasibility, and pollution transport from other regions and countries.

Continued effort to develop cost-effective measures in areas such as San Joaquin Valley where businesses are already subject to the toughest air regulations in the nation is extremely difficult. In fact, both San Joaquin Valley and South Coast concluded that technology did not exist to meet even the 1997 8-hour ozone standard. Meeting the new standards that approach background pollution concentrations require transformative measures that need sufficient time to be planned and implemented. For instance, meeting the latest ozone standard requires eliminating all emissions associated with fossil fuel combustion. The deployment of necessary technology and massive fueling infrastructure is virtually impossible before the current deadline of 2032.

More realistic attainment timelines would allow time for technologies to advance and businesses to develop capital improvement programs to incorporate those technologies in an economically feasible fashion. Additionally, efforts to accurately assess the incremental costs and benefits of new standards would better inform policy makers when reviewing new standards.

Currently, in the San Joaquin Valley, there are six active State Implementation Plans (SIP) in place for ozone and particulate matter, including one for a standard that was revoked. Furthermore, the District is mandate to adopt four additional plans in the next two to three years. There is a great deal of overlap, confusion, and redundancy as multiple plans for the same pollutant are at play.

The CASE Act requires EPA to formally calculate the incremental benefits resulting only from implementing the new standard without adding benefits resulting from implementation of existing standards. Currently, EPA does cite associated health benefits outside of the regulatory process in the public communication literature that accompanies the announcement of the new standards. In doing so EPA often takes credit for health benefits that result from compliance with other existing standards. Some believe that without focus on the incremental benefits of the new standard there is potential to double-count the associated benefits. Additionally, the CASE Act would require that EPA not establish a new ozone standard until at least 85 percent of the counties that were nonattainment areas under the existing standard achieve full compliance with the standard. The ORDEAL Act would extend the period between when EPA would review and set a new ozone standard from the current five year interval to ten years.

Issues to consider in formulating a position on the CASE and ORDEAL Acts
The District does not inherently object to routine review of the health standards and establishment of new standards based upon the latest scientific data. However, as described earlier, the current regiment under the Clean Air Act has led to excessive red tape and administrative burdens without corresponding public health benefit, as well as deadlines that are impossible to meet. However, the District believes that it is possible to continue with the current rigorous regiment for establishing new standards if the implementation mandates are adjusted to avoid redundancy and provide reasonable deadlines that ensure rapid progress toward meeting the standards. These changes can be made with a combination of administration and/or legislative actions at the federal level without any delay in the current standard setting process. Absent these common sense changes to the implementation phase of the Clean Air Act, then the approach taken in the CASE Act and/or the ORDEAL Act may be an appropriate mechanism. Furthermore, these bills might be the only vehicle to focus attention on these issues in the Legislative and Executive branches.

CLEER Act: Commonsense Legislative Exceptional Events Reform (CLEER) Act by Senator Flake, Arizona and Congressman Olson, Texas (Attachment D). These bills were introduced last year and the House bill was cosponsored by Congressman McCarthy and 22 other members of Congress. The bills streamline EPA's exceptional events approval and appeal process. At the District's request, the House bill was amended to include language that clarified that the prolonged and extraordinary drought and related weather conditions similar to those faced by the Valley in 2013/14 should be considered Exceptional Events.

Issues to consider in formulating a position on the CLEER Act

Until the exceptional weather conditions experienced due to the recent drought, the District was on track to attain the 1997 annual PM2.5 standard before the federally mandated deadline of December 2014. The District's *2008 PM2.5 Plan* satisfied all federal implementation requirements for the 1997 PM2.5 standard at the time of adoption and demonstrated attainment based on projected 2012-2014 PM2.5 levels. All emission reduction commitments under that plan have been fulfilled. Due to the extreme drought, stagnation, strong inversions, and historically dry conditions experienced over the winter of 2013/14, the Valley cannot show attainment even if the Valley experienced zero PM2.5 pollution for the last three quarters of 2014.

In addition to the historically strong atmospheric stability, the winter of 2013/14 also experienced record low precipitation totals, with some locations breaking records over 100 years old. These unprecedented dry conditions exacerbated the air quality challenge during the winter of 2013/14. As a result of the extreme meteorology experienced in the Valley, PM2.5 concentrations reached peak levels that had not been recorded in over a decade, which in turn has increased the Valley's federal PM2.5 design values, making the journey to attainment of the PM2.5 standards even more difficult.

The District supported these bills last year and staff recommends that the District support them again if they are reintroduced.

FISCAL IMPACT:

Approval of this item will have no impact upon the District's budget.

Attachments:

- *Attachment A: Draft 2015 Legislative Platform (23 pages)*
- *Attachment B: H.R.5505 CASE Act as Introduced in the 113th Congress (2 pages)*
- *Attachment C: S.2514 and H.R.4947 ORDEAL Act as Introduced in the 113th Congress (8 pages)*
- *Attachment D: S.2526 and H.R.4957 CLEER Act as Introduced in the 113th Congress (13 pages)*

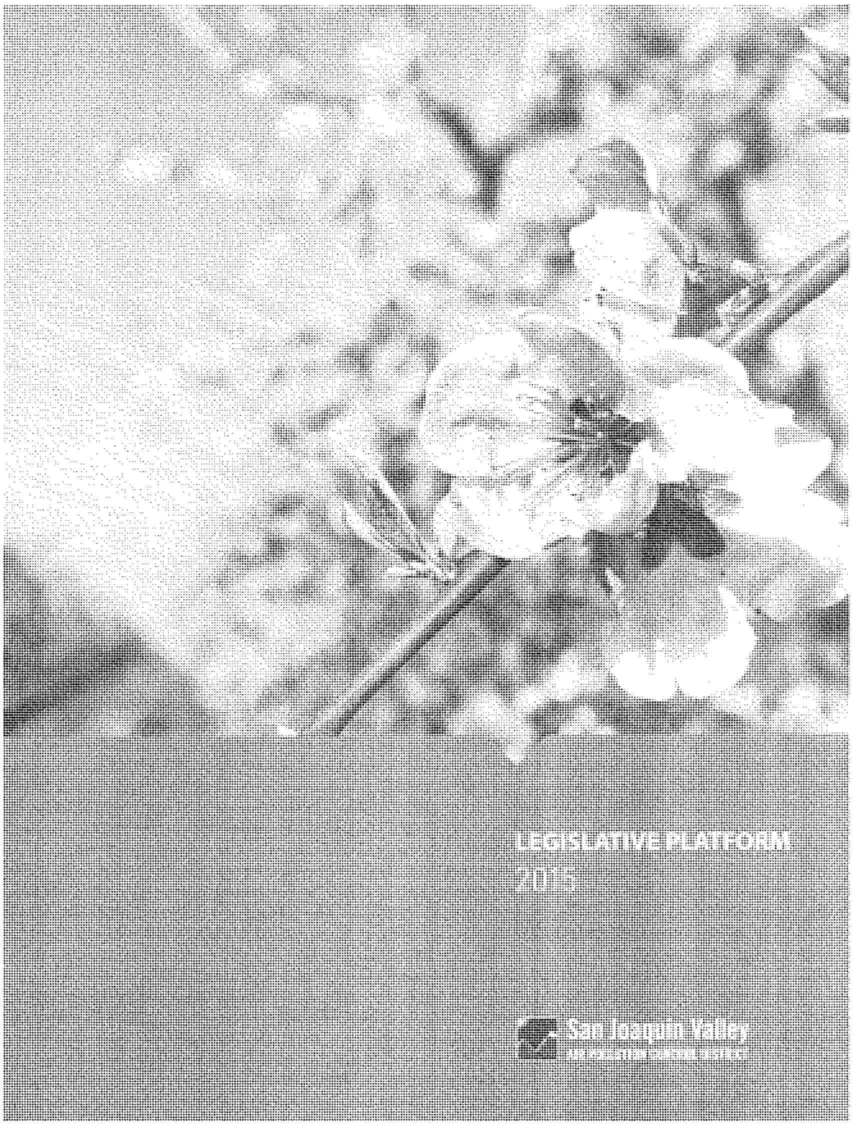
San Joaquin Valley Unified Air Pollution Control District
Meeting of the Governing Board
January 22, 2015

APPROVE THE DISTRICT'S 2015 LEGISLATIVE PLATFORM AND TAKE POSITIONS ON ANTICIPATED FEDERAL AIR QUALITY LEGISLATIVE PROPOSALS

Attachment A:

Draft 2015 Legislative Platform

(23 PAGES)



LEGISLATIVE PLATFORM

2015

San Joaquin Valley

AIR POLLUTION CONTROL DISTRICT

2015 GOVERNING BOARD ROSTER

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Seyed Sadredin - Executive Director/Air Pollution Control Officer

1990 East Gettysburg Avenue
Fresno, CA 93726
(559) 230-6000

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TABLE OF CONTENTS

SAN JOAQUIN VALLEY AIR POLLUTION CONTROL DISTRICT

Jurisdictional Roles	1
Progress to Date	1
Remaining Challenges	5
2015 Legislative Priorities	7
General Legislative Principles	15

Jurisdictional Roles

The **San Joaquin Valley Air Pollution Control District (District)** is the local agency in charge of cleaning the air within the eight county region of the San Joaquin Valley (San Joaquin, Stanislaus, Merced, Madera, Fresno, Tulare, Kings, and the valley portion of Kern County). The District has the primary authority in regulating stationary sources of pollution, such as factories, businesses, and industries. Although state and federal laws preempt the District from setting new tailpipe standards for mobile sources of emissions, the District implements indirect source regulations and incentive-based programs to reduce emissions from on-road and off-road sources of air pollution. The primary authority to regulate emissions from mobile sources of air pollution, such as cars and trucks, lies with the state and federal government. In achieving our clean air goals, the District partners with a number of other governmental agencies:

- The **federal government**, primarily through the Environmental Protection Agency (EPA), sets health-based standards for air pollutants. EPA also controls emissions from trucks, trains, planes and boats and oversees state and local actions to improve air quality.
- The **state government,** through the California Air Resources Board (ARB) and the Bureau of Automotive Repair, develops programs to reduce pollution from vehicles and consumer products. The state also oversees the actions of local air districts and city and county agencies.
- **County and city governments** are responsible for land-use planning to address issues such as "urban sprawl" as well as transportation and mass transit planning.

Progress in cleaning our air is often measured in relation to the health-based standards established by the federal government. The state of California also establishes ambient air quality standards that serve as ultimate goals in achieving clean air.

Progress to date

The Valley's geography and meteorology exacerbate the formation and retention of high levels of air pollution. Surrounding mountains and consistently stagnant weather patterns prevent the dispersal of pollutants that accumulate within the Valley. Temperature inversions, while present to some degree throughout the year, can last for days during the winter, holding in nighttime accumulations of pollutants, including wood smoke.

Due to these unique circumstances, no other region in California faces the enormous degree of difficulty that the Valley faces in meeting the ambient air quality standards for ozone and particulates. This is illustrated by the fact that the San Joaquin Valley has far fewer pollutant emissions per square mile "emission density" than other regions in California that have equivalent or even better air quality.

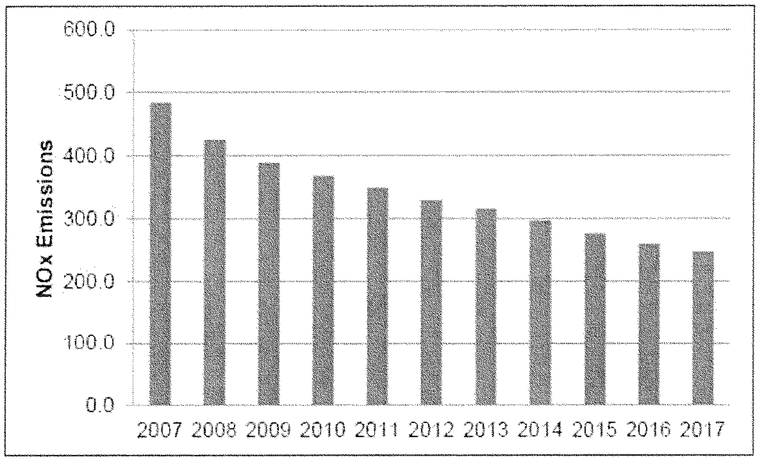
In order to address these challenges, the District has implemented comprehensive regulatory control strategies over the past few decades. Since 1992, the District has adopted over 500 new rules and amendments to implement this aggressive control strategy. In addition, ARB has adopted stringent regulations for heavy-duty trucks, off-road equipment, and other mobile sources. Measured air quality improvements in the Valley document the success of these innovative and effective rules.

These innovative strategies, such as the first-of-its-kind Indirect Source Review regulation that reduces emissions from residential and commercial development, have proven to be highly effective, as evidenced by the steady rate of improvement in the Valley's air quality. The District's incentive program has become an increasingly important and effective strategy for reducing mobile source emissions that the District does not have direct regulatory authority over, with an expenditure of $500 million and a total public/private investment of over $1 billion. These investments have reduced over 100,000 tons of emissions since 1992.

As illustrated in the figure below (Figure 1), the District's control strategies will continue to significantly reduce emissions in the coming years and continue to provide reductions in air pollution.

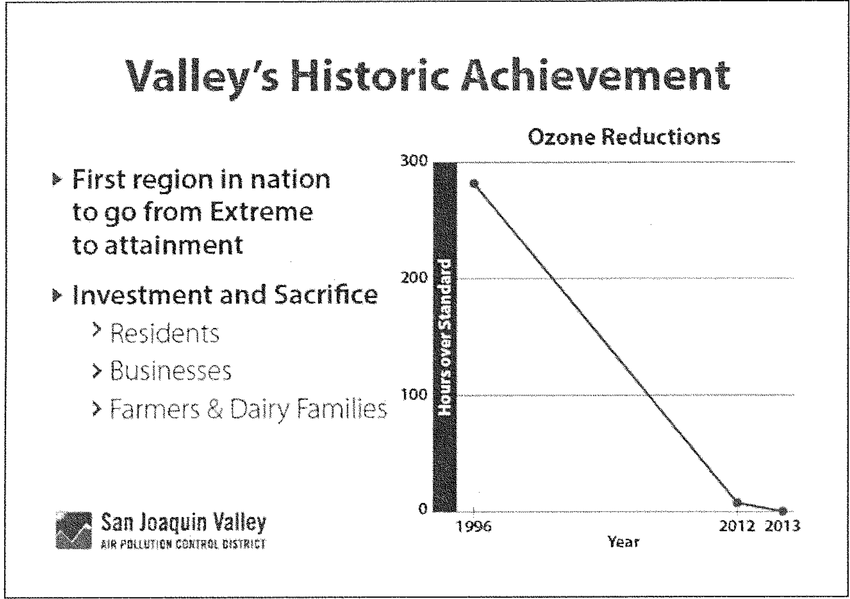
Figure 1

San Joaquin Valley NOx Summer Inventory Trend



The Valley's efforts to reduce emissions have had a dramatic impact upon the Valley's air quality. For the first time in recorded history, the San Joaquin Valley in 2013 had zero violations of the hourly ozone standard established under the federal Clean Air Act. In 2014, the San Joaquin Valley completed an additional ozone season with zero violations of the 1-hour ozone standard. By contrast, in 1996 the Valley experienced 281 hourly exceedances of this standard throughout the eight-county region (see Figure 2). The District has submitted a formal request to the federal Environmental Protection Agency to declare the Valley in attainment of the key standard and lift the $29 million penalty mandate which Valley residents have been paying since late 2010. Reaching this milestone has been the key focus of the Valley's air quality-management strategies for more than two decades. In 2004, EPA classified the Valley as "Extreme" non-attainment for this standard, meaning that reaching the standard, at that time, was deemed impossible.

Figure 2 Reduction in Hours Over 1-Hour Ozone Standard



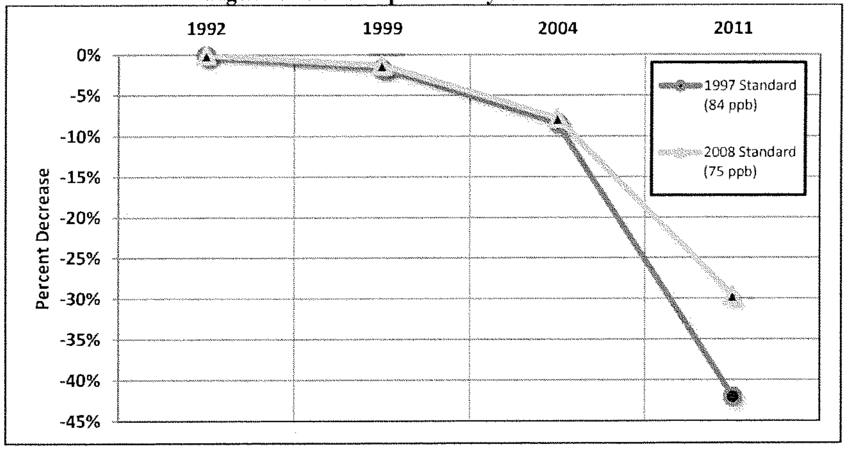
Valley's Historic Achievement

- **First region in nation to go from Extreme to attainment**
- **Investment and Sacrifice**
  - Residents
  - Businesses
  - Farmers & Dairy Families

San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT

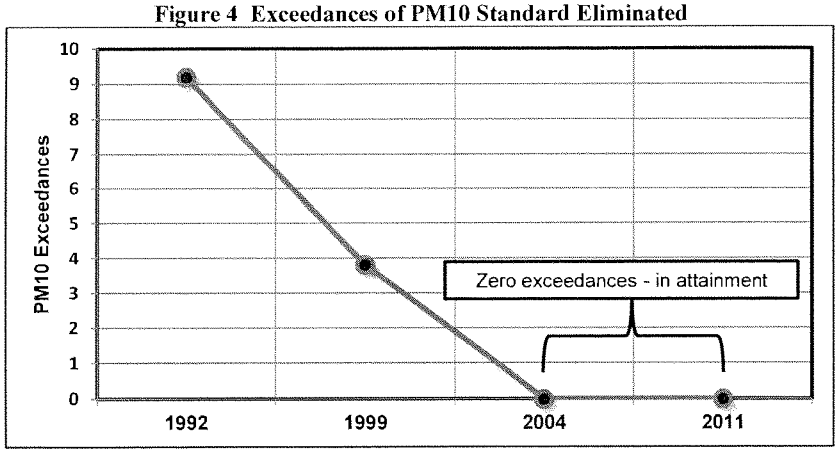
Exceedances of the 1997 and 2008 federal 8-hour ozone standards have dropped by 42% and 30% since 1992, respectively (see Figure 3).

Figure 3 San Joaquin Valley Ozone Trends



In addition to ozone improvements, the Valley has also seen significant improvements in particulate matter levels. The District's residential wood burning curtailments and landmark Conservation Management Practices rule both proved critical in assisting the Valley to eliminate exceedances of the federal PM10 standard and reach attainment of the standard in 2005 (see Figure 4).

Figure 4 Exceedances of PM10 Standard Eliminated



The Valley's 24-hour PM2.5 "design values," used to measure progress relative to the federal standard, have dropped by 40% since 2001, and are now below the 1997 federal 24-hour PM2.5 standard of 65 μg/m^3.

Remaining Challenges

Despite the significant progress that has been made, many air quality challenges remain. EPA has published two standards for 8-hour ozone that the Valley does not meet. The first was published in 1997, and the second was published in 2008. These standards are expressed as a "design value" level. The Valley has seen a downward trend in 8-hour design values, but there is still a long way to go (Figure 5). In order to meet the 1997 federal ozone standard it is estimated that the Valley would need to reduce emissions by 75% from 2005 levels. In developing a plan for that standard, it was determined that the technology does not currently exist to obtain sufficient reductions to meet the standard. Because of this, the Valley was designated as an "extreme" non-attainment area for the 1997 standard. Since that time, EPA has published a new federal ozone standard (2008 Standard) that will require reductions in excess of 90%. Reductions of this magnitude may not be possible without a virtual elimination of fossil fuel combustion and transition to zero-emissions technology (Figure 6). In December, 2014 EPA published yet another ozone standard that will require even further reductions.

Figure 5 Trend in 8-hour Design Value

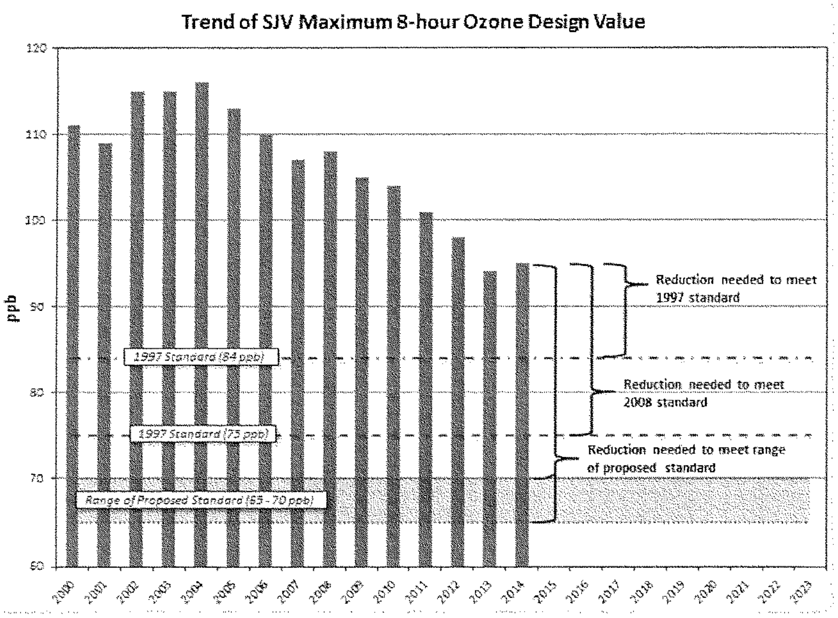
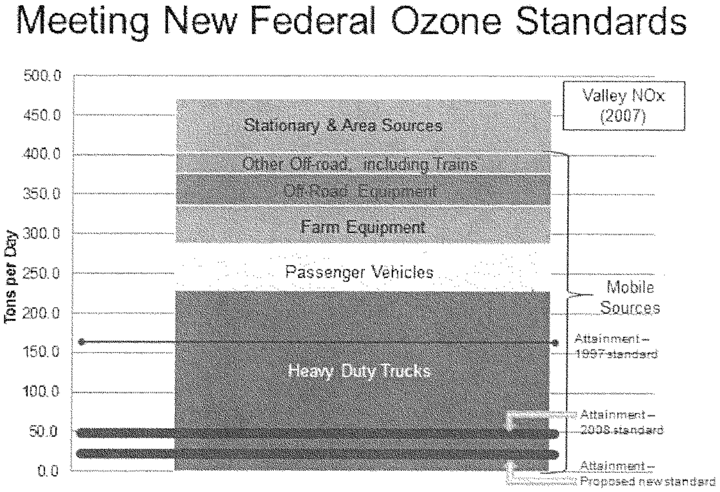


Figure 6 Reductions Needed to Meet 8-hour Standards



Until the exceptional weather conditions experienced due to the recent drought, the District was on track to attain the 1997 annual PM2.5 standard before the federally mandated deadline of December 2014. The District's *2008 PM2.5 Plan* satisfied all federal implementation requirements for the 1997 PM2.5 standard at the time of adoption and demonstrated attainment based on projected 2012-2014 PM2.5 levels. All emission reduction commitments under that plan have been fulfilled. Due to the extreme drought, stagnation, strong inversions, and historically dry conditions experienced over the winter of 2013/14, the Valley cannot show attainment even if the Valley experienced zero PM2.5 pollution for the last three quarters of 2014.

In addition to the historically strong atmospheric stability, the winter of 2013/14 also experienced record low precipitation totals, with some locations breaking records over 100 years old. These unprecedented dry conditions exacerbated the air quality challenge during the winter of 2013/14. As a result of the extreme meteorology experienced in the Valley, PM2.5 concentrations reached peak levels that had not been recorded in over a decade, which in turn has increased the Valley's federal PM2.5 design values, making the journey to attainment of the PM2.5 standards even more difficult.

2015 LEGISLATIVE PRIORITIES

The following legislative priorities will provide policy guidance for legislative action and recognize the unique needs of the District during the upcoming legislative session:

1. **(Federal) Streamline Implementation of the Clean Air Act:** Since its adoption, the Clean Air Act has led to significant improvements in air quality and public health benefits throughout the nation. However, in areas of the nation with mature local air quality management programs, we have reached the point of diminishing returns. After more than 20 years since the last amendments to the Clean Air Act in 1990 (CAA), our experience shows that many well-intentioned provisions are leading to unintended adverse consequences. The antiquated provisions of the Clean Air Act are now leading to confusion, and lack of updated congressional directive has rendered courts as policy makers.

   The District supports the well-intentioned concepts in the Clean Air Act that call for routine review of health-based air quality standards, clean air objectives that are technology-forcing, and clean-air deadlines that ensure expeditious clean-up and timely action. We recommend the Act be amended to allow for consideration of the following critical factors in establishing attainment deadlines and implementation milestones for new standards (A full discussion of these issues can be found in Appendix A):

   - **Upcoming Health Standards and Associated Deadlines are impossible to Meet.** The Clean Air Act requires that EPA set ambient air standards based solely on health impacts and the timelines for meeting the new standards are prescribe by the act with no ability to consider economic or technological feasibility.

     We recommend the Act be amended to allow for consideration of the following critical factors in establishing attainment deadlines and implementation milestones for new standards:

     - Natural environment (climate, geography, topography)
     - Magnitude of the needed emission reductions
     - Availability of technology (maturity of existing control program, time needed to develop new technologies)
     - Economic feasibility
     - Pollution transport from other regions and countries

     The Act should allow region-specific deadlines that take into account the above considerations subject to review and approval by EPA.

   - **The current five year review of standards is too short and has led to overlapping requirements and chaotic transitions between standards.** Under the current system, EPA is finalizing new standards for pollutants prior to a thorough review of plans for the previous standards. Currently, in the San Joaquin Valley there are six active SIPs in place for ozone and particulate matter, including one for a standard that was revoked. There is a great deal of overlap, confusion, and redundancy as multiple plans for the same pollutant are at play.

We recommend a two-fold solution. First, we recommend that the timeline for standard review be extended. Second we recommend that new standards and the associated mandates subsume those associated with the old standard with adequate safeguards to prevent any backsliding.

- **Requiring contingency measures in extreme nonattainment areas is irrational and unnecessary.** The Clean Air Act requires all attainment plans to include contingency measures, defined as extra control measures that go into effect without further regulatory action, if planned emissions controls fail to reach the goals or targets specified in the attainment plan. These requirements do not make sense in "extreme" non-attainment areas, that by definition have already implemented all available and foreseeable measures and still need additional, yet to be identified technologies to reach attainment.

  We recommend that the Act be amended to waive the requirement for contingency measures in areas classified as "extreme" non-attainment by EPA.

- **Section 185 of the Clean Air Act, which requires businesses in "Severe" and "Extreme" non-attainment areas to pay non-attainment penalty fees, is unfair and ineffective.** When Section 185 was first enacted by the United States Congress, it was intended to serve as a hammer compelling stationary sources to install additional controls to reduce emissions and expedite attainment. Given today's circumstances, however, these fees, if applied to stationary sources, will not have the intended impact in San Joaquin Valley. Most stationary sources in the San Joaquin Valley are already equipped with Best Available Retrofit Control Technology (BARCT) or Best Available Control Technology (BACT). Under these circumstances, Section 185 has become a punitive fee with no real ability by most facilities to reduce their emissions. The only options available to Valley businesses to reduce or avoid the fees would be to curtail production or go out of business. Given the Valley's chronic high unemployment rates combined with the current global and regional economic distress, the consequences can be devastating.

  EPA has devised and approved alternative means of complying with Section 185 requirements through the use of revenue from other sources. This approach, however, has been legally challenged by some groups arguing lack of authority by the EPA. To remove legal uncertainty surrounding this matter, we recommend that the Act be amended to repeal Section 185 penalties for businesses that have already employed Best Available Control Technology, or amend the Act to codify the alternative compliance means approved by EPA.

- **The Clean Air Act requirements for severe and extreme ozone nonattainment areas to address vehicle-related emissions growth must be clarified.** CAA section 182(d)(1)(A) requires such areas to develop enforceable transportation control measures (TCMs) and transportation strategies *"to offset any growth in emissions from growth in vehicle miles traveled ... and to attain reduction in motor vehicle emissions as necessary."* An area's vehicle miles traveled (VMT) may increase due to increases in population (i.e., more drivers), people driving further (i.e., sprawl), or increases in pass-through traffic (i.e., goods movement).

  Historically, EPA has allowed the use of vehicle turnover, tailpipe control standards, and the use of alternative fuels to offset the expected increase in VMT and related emissions. A recent court decision, has called EPA's current approach into question. Any change in approach that would require regions to offset vehicle growth regardless of population growth, and without recognition of emission reduction measures such as vehicle turnover and tailpipe control standards, would have a significant impact on many regions' ability to develop an approvable attainment strategy and, under a strict interpretation, would actually render attainment impossible. A less inclusive section 182(d)(1)(A) approach would effectively penalize nonattainment areas for having population growth, and would not give credit to the significant emissions reductions being achieved from motor vehicles. To illustrate this issue, such an interpretation applied to the District's 1997 8-hour ozone standard attainment plan would require the elimination of 5.1 million vehicles, while the vehicle population of the Valley is projected to be only 2.6 million vehicles in 2023.

  EPA established guidance to address this issue that provides a potential path for reasonably addressing this CAA requirement. However, the path provided under this guidance will undoubtedly be challenged in court as it is utilized by regions like the San Joaquin Valley in the coming years. To provide certainty moving forward, the CAA should be amended to clearly include the methodology for reasonably satisfying this requirement.

- **Transition to Health Risk-Based Approach in lieu of the Current Mass Based Approach**. The new standards being considered by EPA encroach on background concentrations in the San Joaquin Valley, and will require significant reductions in emissions from the already lower levels that have been achieved through decades of implementing clean air strategies. In light of these difficult circumstances, it is imperative to craft innovative implementation strategies that enable regions with mature air quality programs to focus efforts on meeting new standards in the most expeditious fashion through deployment of scarce resources in a manner that provides the utmost benefit to public health. Towards that end, we recommend a more strategic approach in which public health serves as the key factor in prioritizing control measures, regulated pollutants, and sources of emissions. Utilizing a "Health Risk-Based" approach in lieu of the current "Mass-Based" approach in implementing health-based standards would provide a more cost effective and health protective framework.

The current mass-based approach can essentially be characterized as a shotgun approach where all pollutants and their species are treated equally regardless of their public health impact. By contrast, a health risk-based approach will be a more strategic approach that targets pollutants and species that have the greatest impact on improving public health. Under the health risk-based approach, the following scientific factors could take taken into account in establishing standards and associated clean air strategies:

- Particle size and surface area
- Chemistry and toxicity
- Effect on formation or reduction of secondary pollutants (e.g., NOx and VOC impact on ozone formation, ammonia and ammonium nitrates)

For example, the latest health research has shown that with regard to PM2.5, not all particles are the same, and that the multiple types of PM2.5 have a significantly varying severity of health effects. EPA has recognized this in its consideration of potential new PM2.5 standards and, while not proposing a strategic approach that takes this science into account, has cited the potential of developing strategies in the future that utilize a more targeted approach than the existing "mass-based approach" that treats all PM2.5 the same.

2. **(State) Increase State Subvention Funding to Provide More Support for Unfunded Mandates:** Local air pollution control and air quality management districts receive subvention funds to support important local air program activities. These funds are allocated from the Motor Vehicle Account through the budget of the California Environmental Protection Agency, under the Air Resources Board section. Local subvention funds were initially provided in 1972, and were increased several times to address the costs of inflation. Despite a significant increase in unfunded mandates, for over twenty years there have been no adjustments for inflation, or added responsibilities. The District, therefore, supports an increase in Subvention funds to help offset increases in costs and responsibility. The District currently receives $900,000 per year which is less than 2% of the District's annual operating budget.

3. **(State) Policies/Guidelines for the Carl Moyer Program:** The Carl Moyer Program has been a valuable source of incentive funds to obtain voluntary emissions reductions from mobile sources of emissions. AB 8 was recently adopted to extend funding for the Carl Moyer program through 2023. The following policies should guide the state as new guidelines/requirements are developed for the program through the new sunset date:

   a) The focus of the Carl Moyer Program should continue to be the reduction of criteria pollutants. Efforts to include greenhouse gas emissions projects should only be considered as co-benefits to projects that are principally designed for the reduction of criteria pollutant emissions.

b) Regional funding formulas should continue to utilize a region's non-attainment status, and the severity of the air quality problem, as the primary factor in determining the regional breakdown of statewide Carl Moyer funding.

c) With respect to regulatory deadlines, incentive funding should be decoupled from regulatory enforcement. Projects that provide cost-effective and surplus emission reductions should be eligible for funding regardless of compliance status with respect to regulatory deadlines.

4. **(State) Cap and Trade Revenues:** The cap and trade program implemented by ARB sets up a mechanism by which affected sources can procure allowances or offsets to meet specified and declining caps on their greenhouse gas emissions. In other words, affected sources will be allowed to invest in reductions in other areas as mitigation for their local emissions. This scenario can potentially lead to adverse impacts in areas that are already disproportionately impacted by criteria pollutant emissions. The Cap and Trade Program generates in excess of $1 billion annually. The state allocates these funds to programs across a number of state agencies. The following overarching policies should be applied as the state considers funding projects and programs from the Greenhouse Gas Reduction Fund:

a) Projects funded with Cap and Trade revenues should achieve greenhouse gas reductions, with priority given to projects that achieve reductions in criteria pollutants as well.

b) A portion of Cap and Trade revenues should be directed to projects in areas that are already disproportionately impacted by air pollution.

c) Policies should be put in place to ensure that programs funded with Cap and Trade revenues meet or exceed the provisions of SB 535 that require a minimum of 25% of the Cap and Trade revenue be spent to benefit disadvantaged communities and that 10% of the revenue be spent in those communities. In determining what communities are disadvantaged, the state is required to prioritize communities that face significant environmental challenges as well as economic challenges.

5. **(State/Federal) Oppose Climate Change Measures that Result in Public Health Detriment Due to Increases in Criteria or Toxic Air Emissions:** Although climate change measures provide for many co-benefits in reducing both greenhouse gasses and criteria pollutant emissions, there are some measures that may lead to increases in criteria pollutant or toxic emissions. Therefore the District will support reasonable climate protection measures that reduce

greenhouse gas emissions as well as toxic and criteria pollutants. The District will oppose climate change measures that are detrimental to public health by leading to increases in toxic or criteria pollutant emissions in already impacted areas.

6. **(State/Federal) Disadvantaged Community Policies:** The San Joaquin Valley is home to a number of disadvantaged communities that deserve care and attention. The District will adhere to the following principles in pursuing efforts to identify and address the needs of these communities:

   a) The District will support measures that improve quality of life and economic welfare. In identifying communities of need, both socioeconomic and environmental impacts should be considered. The District supports CalEPA's California Communities Environmental Health Screening tool (CalEnviroScreen) as the appropriate tool for identifying disadvantaged communities.

   b) The District considers poverty as a key factor contributing to diminished public health and will oppose efforts that lead to "redlining" these communities and inhibit economic growth.

   c) The District will support efforts to target additional state and federal resources to mitigate issues faced in disadvantaged communities.

   d) The District will oppose measures that dilute local control by diverting local revenues or the authority over the expenditure of local resources to the state or federal government. Reduced local control will weaken local enforcement programs. Local agencies are better suited to efficiently and effectively identify and address community needs.

7. **(State/Federal) Seek funding and other support from the State Air Resources Board and Federal Environmental Protection Agency (EPA) to install and operate additional air quality monitoring instruments throughout San Joaquin Valley:** The District operates one of the most extensive air monitoring networks in the nation. Data from these monitors is utilized to measure progress and assess the need for further reductions needed to attain ambient air quality standards established by EPA. Moreover, the District is also committed to providing accurate and timely air quality information to educate and empower the public to protect themselves during poor air quality episodes. This is accomplished utilizing the air monitoring data through the District's first-in-the-nation Real-Time Air Advisory Network (RAAN).

   Installation, operation and maintenance of the Districts air monitoring network is resource intensive. The District's annual operating appropriation for air monitoring is approximately $2.9 million. The increase in federal mandates relating to air monitoring (more monitors and more labor intensive QA/QC and reporting procedures for existing monitors) combined with the need for more monitoring capabilities to satisfy the District's initiative to provide neighborhood by neighborhood air quality information require additional resources.

8. **(State/Federal) Support efforts that provide for cost-effective alternatives to open burning of agricultural waste:** In 2003, state law was amended to require the District to the limit open burning of agricultural material in accordance with a phased-in schedule of deadlines. In addition to those requirements, the state law authorizes the District to postpone the burn prohibition dates for specific types of agricultural material if the District makes three specific determinations and the Air Resources Board (ARB) concurs. The determinations are: (1) there are no economically feasible alternatives to open-burning of the specific type of material; (2) open-burning the specific type of material will not cause or substantially contribute to a violation of a National Ambient Air Quality Standard (NAAQS); and (3) there is no long-term federal or state funding commitment for the continued operation of biomass facilities in the Valley or the development of alternatives to burning. Working closely with the stakeholders over the years to identify economically feasible alternatives to open burning of various agricultural materials, the District has achieved an 80% reduction in agricultural burning.

   Given current energy policy in California, biomass power facilities, which are one of the primary alternatives to agricultural burning, are in jeopardy. Many biomass plants in the Valley are nearing the end of their long-term contracts with utilities and find themselves in a position where the power that they provide is not the type of power that utilities are seeking (baseload vs. intermittent) and that the prices being offered for new contracts are too low to support their operations.

   The District will support efforts to help level the playing field and provide fair competition between biomass plants and other renewable sources of power. The District will also support research and development of alternatives to the open burning of agricultural waste.

9. **(State/Federal) Technology Advancement:** The San Joaquin Valley Air Basin is classified as an "Extreme" non-attainment area for ozone. This means that that technology does not currently exist to bring the region into attainment of the federal ozone standard. Meeting the newest air quality standards will require transformative measures and technologies to achieve near zero emissions. In order to further develop technology to close the gap in required emissions reductions, the District operates a Technology Advancement Program. Along with its own resources, the District is seeking state and federal assistance to advance technology in the following areas:

   a) Mobile sources projects that demonstrate zero- or near-zero-emissions solutions to mobile source categories with emphasis on goods and people movement, off-road equipment, or agricultural equipment.

b) Renewable energy projects that focus on overcoming the barriers that prevent the use or adoption of zero-emission renewable energy sources or reduce emissions from renewable energy systems to make them cleaner than comparable non-renewable alternatives.

c) Waste solutions projects that focus on waste systems or technologies that minimize or eliminate emissions from existing waste management systems and processes, including waste-to-fuel systems, such as dairy digesters and other bio-fuel applications.

10. (State/Federal) Support adequate resources and policies to reduce the impact of wildfires and their attendant public health impact: Wildfires result in significant loss of life and property. Air pollution generated from wildfires is enormous and well exceeds the total industrial and mobile source emissions in the San Joaquin Valley. These emissions result in significant adverse public health impacts in the San Joaquin Valley and in many regions throughout California. In the summer of 2008, California experienced a record number of wildfires, and the resulting emissions caused serious public health impacts and unprecedented levels of PM2.5 and ozone in the San Joaquin Valley and other regions throughout the state. Historically clean rural areas throughout the state and in the San Joaquin Valley experienced their worst air quality in decades, and pollutant levels and the number of daily exceedances of the health-based standards were significantly higher than ever before in recorded history.

Reducing wildfires and the resulting air pollutants requires a sustained and multi-faceted approach that employs effective measures to reduce fuel supplies and adequate resources to manage fires when they occur. Towards that end, the San Joaquin Valley Air Pollution Control District supports policies and initiatives that would encourage rapid disposal of the fuel supply, including the following:

a. Additional financial and staffing resources for public and private land managers to conduct prescribed burning as an effective means for reducing fuel supplies that lead to large and uncontrollable wildfires.

b. Additional resources to manage wildfires when they occur.

c. Lessening or removal of contradictory environmental protection policies that prohibit the use of mechanized methods, or prescribed burning to reduce fuels when those are the only feasible methods available.

d. Changes in the federal policies that better incorporate air quality concerns by shifting focus to prescribed burning and employing fire management techniques that reduce air quality impact when wildfires occur.

GENERAL PRINCIPLES OF THE LEGISLATIVE PLATFORM

The following general principles will provide policy guidance for legislative action:

LOCAL: To fulfill the goals of the District, to maintain the ability to develop and implement control strategies to address stationary and area pollutants, and to achieve ambient air quality standards, the following principles will guide District policy:

1. Support legislation that retains the Governing Board's control over the use of emission reduction credits (ERCs) throughout the Valley.
2. Oppose legislation that usurps the District's authority to determine the cost-effectiveness of proposed District rules.
3. Support legislation that encourages the management of air quality on a regional basis, particularly in the Valley, and not on a statewide basis, in order to assure that local concerns are recognized.
4. Support and actively advocate increases in the District Subvention based on inflation and increased mandates.
5. Support legislation that retains local enforcement and discretionary authority for Notices to Comply/Notices of Violation (NTC/NOV fines, adjudication, etc.).
6. Support legislation that promotes the creation and use of District-operated self-audit and inspection programs. Such legislation will enhance the District's ability to offer incentive- based programs to Valley businesses in ways that do not conflict with state and federal law.
7. Oppose all legislation that transfers any part of local permitting authority to the state or federal governments. Past transfers of the District's permitting authority have proved to prolong the permitting process without any corresponding benefit to air quality.
8. Oppose legislation that limits the District's ability to regulate the installation or utilization of wood-burning fireplaces and wood-burning heaters.

PROPORTIONAL MOBILE AND STATIONARY SOURCE CONTROLS: To achieve emissions reductions that are adequate to attain air quality standards, it is imperative that all sources are adequately controlled according to their contribution the Valley's air quality challenges. In order to achieve this objective, the following principles will guide District policy.

1. Continue to support legislation that requires the USEPA to develop and implement programs that effectively and efficiently control interstate mobile

sources including, but not limited to, trains, trucks, boats, and planes. Support federal actions that will provide cleaner operating vehicles. Support legislation that requires improved emission standards for buses.

2. Support legislation that requires federal sources, including trains, trucks and ships, to contribute their "fair share" of the emission reductions required for attainment of air quality standards in the San Joaquin Valley. This would include mitigating emissions associated with the implementation of the North American Free Trade Agreement, requiring more stringent controls on locomotives, and reducing emissions from ships while they are in port.

STATE/FEDERAL: To support state and federal means of addressing, without duplication, the need for better air quality in the San Joaquin Valley, and to support state and federal actions that are effective and economically feasible, the following principles will guide District policy:

1. Support state and federal legislation that would preserve and enhance the ability of local governments to adequately finance mandated and essential services.

2. Support federal legislation or regulations that alleviate administrative burdens that are unnecessary for the protection of air quality, associated with permitting requirements.

3. Support legislation to streamline the permitting process at the local level that is efficient and effective. Oppose legislation that negatively affects the District's ability to protect and improve air quality.

4. Support legislation to reduce the duplicative oversight responsibilities of state agencies and boards vis a vis the regional air districts.

5. Support legislation that eliminates duplication between state and federal air quality agencies. Allow a single permit system that satisfies both state and federal regulations. California has the strictest air quality standards in the country. Federal duplication only hinders business and does not improve air quality.

6. Sponsor or support legislative options that would increase funding to the District to develop Valley-specific options for attainment.

7. Support legislation that promotes energy conservation and efficiency programs for energy end-users. Reduced energy use will result in lower pollutant emissions and a more stable electrical distribution system.

8. Support legislation that allows "net metering" or feed in tariffs for alternative energy projects.

9. Support legislation that encourages low-emission utilization of waste gas as an alternative to waste gas venting or flaring.

10. Seek adequate funding from ARB and EPA to implement state and federal air quality mandates.

11. Oppose efforts to allow the sale and use of safe and sane fireworks outside of the period surrounding the 4th of July.

12. The District supports the establishment of an Air Quality and Health Empowerment Zone Designation that would provide financial assistance to regions that have significant air quality, health, and economic challenges. This new program would provide financial assistance for incentive programs in areas that face significant air quality, health, and economic challenges. Given the Valley's air quality challenges and continued double digit unemployment rates, the Valley would be a prime candidate for designation under this new program. The program would provide a mechanism for ongoing appropriations for incentive programs to accelerate the introduction of new emissions reduction technologies.

MOBILE SOURCE AND TRANSPORTATION: To address issues dealing with mobile source reductions and transportation alternatives; to achieve mobile source reductions in addition to those currently approved in air attainment plans; to create market-based incentives for mobile source emissions; and to encourage and promote public transportation improvements; the following principles will guide District policy:

1. Support funding for mobile source reductions.

2. Support legislation that provides options for local air districts for pilot incentives to reduce mobile source emissions.

3. Support state and federal legislation and regulations to further promote cost-effective and clearly defined strategies associated with vehicle emission reductions and effective statewide vehicle Inspection & Maintenance programs.

4. Support legislation to assist regional transportation authorities' efforts for multi-modal transit systems that ensure ongoing growth in ridership by promoting and encouraging maximum public use.

5. Support measures that will improve the efficiency and effectiveness of the smog check program including reducing testing cost, better mechanisms to identify high emitters, and enhanced oversight of the smog-check stations.

6. Support legislation and efforts to enhance interregional transit options that provide an alternative to driving. This should include options for the movement of both people and goods within the San Joaquin Valley and to adjacent regions.

7. Oppose legislation that restricts the District's use of Governing Board-authorized funds for cost effective emission control projects.

8. Support legislation that simplifies Transportation Conformity compliance and synchronizes conformity related transportation planning requirements with air quality planning requirements and deadlines.

9. Support legislation that puts organizational structures in place that facilitate inter-regional and intra-regional solutions for the efficient movement of people and goods through the San Joaquin Valley utilizing a variety of transportation modes.

10. Support air quality funding and programs in the federal transportation bill re-authorization. The following are general principles to guide the District during the development of federal surface transportation reauthorization legislation.

    a. Transportation Sources and Air Pollution-Provisions should be included which improve air quality and reduce health impacts on the public.

    b. Congestion Relief and Air Quality-Transportation projects designed to reduce congestion must also be designed to help improve air quality.

    c. Projects with Specific Air Quality Benefits-Programs in the bill should ensure that a sizeable portion of federal transportation funds should be reserved for purposes that are designed to substantially reduce air pollution in the transportation sector.

    d. Conformity Provisions Must Be Strengthened-Efforts should be made to strengthen existing "transportation conformity" requirements so they implement all feasible emission reductions and achieve the reductions needed for long-term air quality attainment.

    e. Funded Projects Should Achieve Emissions Benefits Commensurate with Regional Air Quality Needs -Pollution reductions should be sufficient so that the transportation sector contributes its fair share to timely attainment of National Ambient Air Quality Standards. Needed emission control actions may vary by area with the most aggressive emission controls required in areas with the most difficult attainment challenges.

    f. Urge Zero-Emission Technologies in "Extreme" Ozone Nonattainment Areas-Due to the large additional emission reductions needed in Extreme Ozone nonattainment areas, programs should be established for projects that utilize zero emission technologies, including, but not limited to, electrification.

g. GHG Emissions and Criteria Pollutants-Projects that reduce or offset greenhouse gas emissions, or contribute to a set-aside-fund for GHG reduction, should be included and efforts to reduce greenhouse gas emission levels should be undertaken in concert with efforts to reduce criteria and toxic pollutants. Actions to produce GHG offsets should not result in greater emissions of toxic or criteria pollutants.

h. Authorize Projects Reducing Emissions-Priority consideration should be made to authorize funding for projects that support the long-term attainment needs of an area, including, but not limited to programs that
   - include or facilitate the use of public transit and efficient rail,
   - are built with the cleanest construction equipment available, and
   - include the use of low-emission equipment where state and local governments would be preempted from requiring emission controls.

i. Funding Requirements-Programs that achieve transportation goals should be designed with requirements, conditions, or even mandates that ensure that projects funded through those programs achieve documented air quality benefits.

j. Funding sources-Alternative and creative sources of funding which increase the amount of funds allocated for surface transportation and/or air quality should be encouraged.

k. Air Quality Agency Participation in Decision Making Process-Decisions to fund projects or programs should be made with involvement by state air quality agencies or, in states which have local air quality agencies, by such local agencies and such funding must be consistent with the respective State Implementation Plan. At a minimum, air agencies should approve emissions impact estimates and determine compliance with air quality funding criteria, such as those specified above.

l. Increase Maximum Truck Weight Limit-The District supports increasing the federal truck weight limit to 97,000 provided any potential safety and highway maintenance issues are addressed.

ALTERNATIVE COMPLIANCE OPTIONS: To have the ability to provide for compliance flexibility when dealing with businesses addressing air quality rules and regulations, and to ensure that alternative compliance options provide adequate measures to at least meet the required emission reductions necessary, the following principles will guide District policy:

1. Support legislation that provides for market-based incentives that achieve equivalent reduction in air emissions in a more cost-effective fashion.

2. Oppose legislation that diminishes the District's ability to write permits that are practical and enforceable.

3. Support legislation that would prohibit an increase in assessed property value for new equipment installed solely for the purpose of meeting the requirements of District Rules and Regulations.

4. Support legislation that encourages the generation of mobile source emission reduction credits.

TOXIC AIR EMISSIONS: To ensure the protection of public health and to minimize exposure to significant toxic pollutants, the following principles will guide District policy:

1. Oppose legislation that results in the release of cancer-causing and other toxic emissions in quantities that pose significant risks to public health.

2. Support legislation that upholds the requirement for public notification when significant toxic pollutants are located in close proximity to a given neighborhood.

3. Support legislation that allows for the integration of state and federal air toxic mandates while protecting public health.

4. Support legislation that calls for cleaner-burning alternative fuels.

5. Support measures that result in early risk reduction without costly and unnecessary risk assessment work.

San Joaquin Valley Unified Air Pollution Control District
Meeting of the Governing Board
January 22, 2015

APPROVE THE DISTRICT'S 2015 LEGISLATIVE PLATFORM AND TAKE POSITIONS ON ANTICIPATED FEDERAL AIR QUALITY LEGISLATIVE PROPOSALS

Attachment B:

H.R. 5505 CASE Act as Introduced in the 113th Congress

(2 PAGES)

I

113TH CONGRESS
2D SESSION

H. R. 5505

To improve the establishment of any lower ground-level ozone standards, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

SEPTEMBER 17, 2014

Mr. OLSON (for himself, Mr. LATTA, Mr. SHIMKUS, Mr. WEBER of Texas, Mr. CASSIDY, Mr. FLORES, Mr. SMITH of Texas, Mr. HALL, Mr. MCCLINTOCK, Mr. HULTGREN, Mr. TIPTON, Mr. MCKINLEY, Mr. SMITH of Missouri, Mr. JONES, Mrs. NOEM, Mrs. LUMMIS, Mr. POMPEO, Mr. HARPER, Mr. BRADY of Texas, Mr. LONG, Mr. JOHNSON of Ohio, and Mr. CUELLAR) introduced the following bill; which was referred to the Committee on Energy and Commerce

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A BILL

To improve the establishment of any lower ground-level ozone standards, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Clean Air, Strong Economies Act".

SEC. 2. GROUND-LEVEL OZONE STANDARDS.

Notwithstanding any other provision of law (including regulations), in promulgating a national primary or secondary ambient air quality standard for ozone, the Administrator of the Environmental Protection Agency—

(1) shall not propose a national primary or secondary ambient air quality standard for ozone that is lower than the standard established under section 50.15 of title 40, Code of Federal Regulations (as in effect on January 1, 2014), until at least 85 percent of the counties that were nonattainment areas under that standard as of January 1, 2014, achieve full compliance with that standard;

(2) shall only consider all or part of a county to be a nonattainment area under the standard on the basis of direct air quality monitoring;

(3) shall take into consideration feasibility and cost; and

(4) shall include in the regulatory impact analysis for the proposed and final rule at least 1 analysis that does not include any calculation of benefits resulting from reducing emissions of any pollutant other than ozone.

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San Joaquin Valley Unified Air Pollution Control District
Meeting of the Governing Board
January 22, 2015

APPROVE THE DISTRICT'S 2015 LEGISLATIVE PLATFORM AND TAKE POSITIONS ON ANTICIPATED FEDERAL AIR QUALITY LEGISLATIVE PROPOSALS

Attachment C:

S.2514 and H.R.4947 ORDEAL Act as Introduced in the 113th Congress

(8 PAGES)

II

113TH CONGRESS
2D SESSION

S. 2514

To amend the Clean Air Act to delay the review and revision of the national ambient air quality standards for ozone.

IN THE SENATE OF THE UNITED STATES

JUNE 24, 2014

Mr. FLAKE (for himself, Mr. MCCAIN, Mr. RISCH, Mr. WICKER, Mr. CRAPO, Mr. SESSIONS, Mr. JOHNSON of Wisconsin, Mr. VITTER, Mr. ENZI, Mr. BARRASSO, Mr. COATS, Mr. CORNYN, and Mr. THUNE) introduced the following bill; which was read twice and referred to the Committee on Environment and Public Works

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A BILL

To amend the Clean Air Act to delay the review and revision of the national ambient air quality standards for ozone.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Ozone Regulatory Delay and Extension of Assessment Length Act of 2014" or the "ORDEAL Act of 2014".

SEC. 2. NATIONAL AMBIENT AIR QUALITY STANDARDS.

Section 109(d) of the Clean Air Act (42 U.S.C. 7409(d)) is amended—

(1) in paragraph (1)—

(A) in the first sentence, by striking "(d)(1) Not later than December 31, 1980, and at five-year intervals" and inserting the following:

"(d) REVIEW AND REVISION OF CRITERIA AND STANDARDS; INDEPENDENT SCIENTIFIC REVIEW COMMITTEE; APPOINTMENT; ADVISORY FUNCTIONS.—

"(1) REVIEW AND REVISION OF CRITERIA AND STANDARDS.—

"(A) IN GENERAL.—Except as provided in subparagraph (C), not later than December 31, 1980, and at 10-year intervals";

(B) in the second sentence, by striking "The Administrator" and inserting the following:

"(B) EARLY AND FREQUENT REVIEW AND REVISION.—Except with respect to any national ambient air quality standard promulgated under this section for ozone concentrations, the Administrator"; and

(C) by adding at the end the following:

"(C) NATIONAL AMBIENT AIR QUALITY STANDARDS FOR OZONE CONCENTRATIONS.—Not earlier than February 1, 2018, but not later than December 31, 2018, and at 10-year intervals thereafter, the Administrator shall, with respect to national ambient air quality standards for ozone concentrations—

"(i) complete a thorough review of any standard promulgated under this section; and

"(ii) make revisions to the standards described in clause (i) and promulgate new standards as may be appropriate in accordance with section 108 and subsection (b)."; and

(2) in paragraph (2)(B)—

(A) by striking "(B) Not later than January 1, 1980, and at five-year intervals" and inserting the following:

"(B) REVIEW.—

"(i) IN GENERAL.—Except as provided in clause (ii), not later than January 1, 1980, and at 10-year intervals"; and

(B) by adding at the end the following:

"(ii) NATIONAL AMBIENT AIR QUALITY STANDARDS FOR OZONE CONCENTRATIONS.—Not earlier than February 1, 2018, and at 10-year intervals thereafter, the committee referred to in subparagraph (A) shall, with respect to national ambient air quality standards for ozone concentrations—

"(I) complete a review of any standard promulgated under this section; and

"(II) recommend to the Administrator any new standard and any revision to the standards described in subclause (I) as may be appropriate under section 108 and subsection (b).".

○

I

113TH CONGRESS
2D SESSION

H. R. 4947

To amend the Clean Air Act to delay the review and revision of the national ambient air quality standards for ozone.

IN THE HOUSE OF REPRESENTATIVES

JUNE 24, 2014

Mr. SALMON (for himself and Mr. OLSON) introduced the following bill; which was referred to the Committee on Energy and Commerce

---

A BILL

To amend the Clean Air Act to delay the review and revision of the national ambient air quality standards for ozone.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Ozone Regulatory Delay and Extension of Assessment Length Act of 2014" or the "ORDEAL Act of 2014".

SEC. 2. NATIONAL AMBIENT AIR QUALITY STANDARDS.

Section 109(d) of the Clean Air Act (42 U.S.C. 7409(d)) is amended—

(1) in paragraph (1)—

(A) in the first sentence, by striking "(d)(1) Not later than December 31, 1980, and at five-year intervals" and inserting the following:

"(d) REVIEW AND REVISION OF CRITERIA AND STANDARDS; INDEPENDENT SCIENTIFIC REVIEW COMMITTEE; APPOINTMENT; ADVISORY FUNCTIONS.—

"(1) REVIEW AND REVISION OF CRITERIA AND STANDARDS.—

"(A) IN GENERAL.—Except as provided in subparagraph (C), not later than December 31, 1980, and at 10-year intervals";

(B) in the second sentence, by striking "The Administrator" and inserting the following:

"(B) EARLY AND FREQUENT REVIEW AND REVISION.—Except with respect to any national ambient air quality standard promulgated under this section for ozone concentrations, the Administrator"; and

(C) by adding at the end the following:

"(C) NATIONAL AMBIENT AIR QUALITY STANDARDS FOR OZONE CONCENTRATIONS.—Not earlier than February 1, 2018, but not later than December 31, 2018, and at 10-year intervals thereafter, the Administrator shall, with respect to national ambient air quality standards for ozone concentrations—

"(i) complete a thorough review of any standard promulgated under this section; and

"(ii) make revisions to the standards described in clause (i) and promulgate new standards as may be appropriate in accordance with section 108 and subsection (b)."; and

(2) in paragraph (2)(B)—

(A) by striking "(B) Not later than January 1, 1980, and at five-year intervals" and inserting the following:

"(B) REVIEW.—

"(i) IN GENERAL.—Except as provided in clause (ii), not later than January 1, 1980, and at 10-year intervals"; and

(B) by adding at the end the following:

"(ii) NATIONAL AMBIENT AIR QUALITY STANDARDS FOR OZONE CONCENTRATIONS.—Not earlier than February 1, 2018, and at 10-year intervals thereafter, the committee referred to in subparagraph

(A) shall, with respect to national ambient air quality standards for ozone concentrations—

"(I) complete a review of any standard promulgated under this section; and

"(II) recommend to the Administrator any new standard and any revision to the standards described in subclause (I) as may be appropriate under section 108 and subsection (b).".

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San Joaquin Valley Unified Air Pollution Control District
Meeting of the Governing Board
January 22, 2015

APPROVE THE DISTRICT'S 2015 LEGISLATIVE PLATFORM AND TAKE POSITIONS ON ANTICIPATED FEDERAL AIR QUALITY LEGISLATIVE PROPOSALS

Attachment D:

S.2526 and H.R.4957 CLEER Act as Introduced in the 113th Congress

(13 PAGES)

113TH CONGRESS
2D SESSION

S. 2526

To amend the Clean Air Act with respect to exceptional event demonstrations, and for other purposes.

IN THE SENATE OF THE UNITED STATES

JUNE 25, 2014

Mr. FLAKE (for himself, Mr. MCCAIN, Mr. RISCH, Mr. CRAPO, Mr. INHOFE, Mr. SESSIONS, Mr. JOHNSON of Wisconsin, Mr. VITTER, Mr. HATCH, Mr. CORNYN, and Mr. THUNE) introduced the following bill; which was read twice and referred to the Committee on Environment and Public Works

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A BILL

To amend the Clean Air Act with respect to exceptional event demonstrations, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Commonsense Legislative Exceptional Events Reforms Act of 2014".

SEC. 2. CLEAN AIR ACT EXCEPTIONAL EVENTS.

Section 319(b) of the Clean Air Act (42 U.S.C. 7619(b)) is amended—

(1) in paragraph (1)(B)—

(A) in clause (i), by inserting "or" after the semicolon;

(B) by striking clause (ii); and

(C) by redesignating clause (iii) as clause (ii); and

(2) in paragraph (3)—

(A) in subparagraph (B)(iv), by striking "to petition the Administrator to" and inserting "to submit a petition (in this section referred to as an 'exceptional event demonstration') to the Administrator to"; and

(B) by adding at the end the following:

"(C) CRITERIA FOR DETERMINATION OF EXCEPTIONAL EVENT DEMONSTRATION.—

"(i) IN GENERAL.—The criteria for evidence, analyses, and documentation applicable to approval or disapproval of an exceptional event demonstration under the regulations under this section shall be stated with specificity in order to minimize the discretion of the Administrator in approving or disapproving that demonstration.

"(ii) STATE PARTICIPATION.—The Administrator shall develop the criteria in conjunction with input from the States.

"(iii) CONTENTS.—The criteria shall reflect the varying levels of technical expertise and resources available in State and local agencies and the varying availability of meteorological and other monitoring data in rural areas, and may vary with respect to different regions.

"(iv) CONSIDERATIONS.—In developing the criteria, the Administrator shall consider the use of an expedited or streamlined approval process and conditions under which exceptional event demonstrations may be suitable for such a process.

"(D) TIMING OF DETERMINATION OF EXCEPTIONAL EVENT DEMONSTRATION.—

"(i) DEADLINE FOR DETERMINATION.—

"(I) IN GENERAL.—Not later than 90 days after submission of an exceptional event demonstration, the Administrator shall approve, disapprove, or request additional information from a State regarding the exceptional event demonstration.

"(II) ADMINISTRATION.—If the Administrator does not approve, disapprove, or request additional information relating to an exceptional event demonstration within the 90-day period described in subclause (I), the demonstration shall be considered to be approved on the day after the date on which that 90-day period ends.

"(ii) DEADLINE IF ADDITIONAL INFORMATION REQUESTED.—

"(I) IN GENERAL.—If the Administrator requests additional information from a State regarding an exceptional event demonstration under clause (i), not later than 90 days after the submission of that additional information, the Administrator shall approve or disapprove the demonstration.

"(II) ADMINISTRATION.—If the Administrator does not approve or disapprove a demonstration for which additional information is submitted within the 90-day period described in subclause (I), the demonstration shall be considered to be approved.

"(E) BURDEN OF PROOF.—The regulations promulgated under this section shall provide that—

"(i) a determination by the Administrator with respect to approval or disapproval of an exceptional event demonstration be based on a preponderance of the evidence; and

"(ii) in making a determination, the Administrator—

"(I) shall accord substantial deference to the findings of the State exceptional event demonstration; and

"(II) may develop and use analyses and consider evidence not provided in the exceptional event demonstration, subject to the condition that the analyses are developed by the Environmental Protection Agency.

"(F) APPEALS.—

"(i) DISAPPROVAL.—

"(I) IN GENERAL.—Subject to subclause (II), disapproval by the Administrator of an exceptional event demonstration shall be considered final action subject to judicial review under section 307(b).

"(II) LIMITATION.—Notwithstanding subclause (I), disapproval by the Administrator of an exceptional event demonstration shall only be subject to appeal by the State that submitted the exceptional event demonstration.

"(ii) APPROVAL.—Approval by the Administrator of an exceptional event demonstration shall not be subject to appeal or other judicial action.".

SEC. 3. REVISION OF REGULATIONS.

After providing for a notice and comment period, but not later than 180 days after the date of enactment of this Act, the Administrator of the Environmental Protection Agency shall revise the regulations under section 319(b) of the Clean Air Act (42 U.S.C. 7619(b)) to carry out the amendments made by this Act.

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113TH CONGRESS
2D SESSION

H. R. 4957

To amend the Clean Air Act with respect to exceptional event demonstrations, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

JUNE 25, 2014

Mr. OLSON (for himself, Mr. MCCARTHY of California, Mr. MCCLINTOCK, Mr. SCHWEIKERT, Mr. STOCKMAN, Mr. CHAFFETZ, Mr. PEARCE, Mr. POMPEO, Mr. CAMPBELL, Mr. TIPTON, Mr. SALMON, Mr. WEBER of Texas, Mr. DUNCAN of South Carolina, Mr. GOSAR, Mr. POE of Texas, Mr. FRANKS of Arizona, Mr. NEUGEBAUER, Mr. MARCHANT, Mr. CULBERSON, Mr. CONAWAY, Mr. LATTA, Mr. WILLIAMS, and Mr. KELLY of Pennsylvania) introduced the following bill; which was referred to the Committee on Energy and Commerce

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A BILL

To amend the Clean Air Act with respect to exceptional event demonstrations, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Commonsense Legislative Exceptional Events Reforms Act of 2014".

SEC. 2. CLEAN AIR ACT EXCEPTIONAL EVENTS.

Section 319(b) of the Clean Air Act (42 U.S.C. 7619(b)) is amended—

(1) in paragraph (1)(B)—

(A) in clause (i)—

(i) by striking "(i) stagnation of air masses or" and inserting "(i)(I) ordinarily occurring stagnation of air masses or (II)"; and

(ii) by inserting "or" after the semicolon;

(B) by striking clause (ii); and

(C) by redesignating clause (iii) as clause (ii); and

(2) in paragraph (3)—

(A) in subparagraph (B)(iv), by striking "to petition the Administrator to" and inserting "to submit a petition (in this section referred to as an 'exceptional event demonstration') to the Administrator to"; and

(B) by adding at the end the following:

"(C) CRITERIA FOR DETERMINATION OF EXCEPTIONAL EVENT DEMONSTRATION.—

"(i) IN GENERAL.—The criteria for evidence, analyses, and documentation applicable to approval or disapproval of an exceptional event demonstration under the regulations under this section shall be stated with specificity in order to minimize the discretion of the Administrator in approving or disapproving that demonstration.

"(ii) STATE PARTICIPATION.—The Administrator shall develop the criteria in conjunction with input from the States.

"(iii) CONTENTS.—The criteria shall reflect the varying levels of technical expertise and resources available in State and local agencies and the varying availability of meteorological and other monitoring data in rural areas, and may vary with respect to different regions.

"(iv) CONSIDERATIONS.—In developing the criteria, the Administrator shall consider the use of an expedited or streamlined approval process and conditions under which exceptional event demonstrations may be suitable for such a process.

"(D) TIMING OF DETERMINATION OF EXCEPTIONAL EVENT DEMONSTRATION.—

"(i) DEADLINE FOR DETERMINATION.—

"(I) IN GENERAL.—Not later than 90 days after submission of an exceptional event demonstration, the Administrator shall approve, disapprove, or request additional information from a State regarding the exceptional event demonstration.

"(II) ADMINISTRATION.—If the Administrator does not approve, disapprove, or request additional information relating to an exceptional event demonstration within the 90-day period described in subclause (I), the demonstration shall be considered to be approved on the day after the date on which that 90-day period ends.

"(ii) DEADLINE IF ADDITIONAL INFORMATION REQUESTED.—

"(I) IN GENERAL.—If the Administrator requests additional information from a State regarding an exceptional event demonstration under clause (i), not later than 90 days after the submission of that additional information, the Administrator shall approve or disapprove the demonstration.

"(II) ADMINISTRATION.—If the Administrator does not approve or disapprove a demonstration for which additional information is submitted within the 90-day period described in subclause (I), the demonstration shall be considered to be approved.

"(E) BURDEN OF PROOF.—The regulations promulgated under this section shall provide that—

"(i) a determination by the Administrator with respect to approval or disapproval of an exceptional event demonstration be based on a preponderance of the evidence; and

"(ii) in making a determination, the Administrator—

"(I) shall accord substantial deference to the findings of the State exceptional event demonstration; and

"(II) may develop and use analyses and consider evidence not provided in the exceptional event demonstration, subject to the condition that the analyses are developed by the Environmental Protection Agency.

"(F) APPEALS.—

"(i) DISAPPROVAL.—

"(I) IN GENERAL.—Subject to subclause (II), disapproval by the Administrator of an exceptional event demonstration shall be considered final action subject to judicial review under section 307(b).

"(II) LIMITATION.—Notwithstanding subclause (I), disapproval by the Administrator of an exceptional event demonstration shall only be subject to appeal by the State that submitted the exceptional event demonstration.

"(ii) APPROVAL.—Approval by the Administrator of an exceptional event demonstration shall not be subject to appeal or other judicial action.".

SEC. 3. REVISION OF REGULATIONS.

After providing for a notice and comment period, but not later than 180 days after the date of enactment of this Act, the Administrator of the Environmental Protection Agency shall revise the regulations under section 319(b) of the Clean Air Act (42 U.S.C. 7619(b)) to carry out the amendments made by this Act.

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Accepted for Publication by the Air & Waste Management Association (AWMA) Journal *Environmental Manager*
Permission was granted from AWMA to submit this manuscript to the SS&T Committee

Lowering the ozone standard will not measurably improve public health

Bryan W. Shaw, Ph.D., P.E.; Sabine S. Lange, Ph.D.; and Michael E. Honeycutt, Ph.D.
Texas Commission on Environmental Quality, Austin, Texas

Bryan Shaw (512-239-5510, Bryan.Shaw@tceq.texas.gov) is Chairman of the TCEQ; Sabine Lange (512-239-3108, Sabine.Lange@tceq.texas.gov) is a toxicologist in the Toxicology Division of the TCEQ; and Michael Honeycutt (512-239-1793, Michael.Honeycutt@tceq.texas.gov) is the director of the Toxicology Division of the TCEQ.

The Texas Commission on Environmental Quality (TCEQ) strives to protect our state's public health and natural resources consistent with sustainable economic development. In accordance with this mission, the State of Texas alone has spent >$1B since 2001 striving to achieve the 1997 0.08 ppm ozone standard. Most of Texas' air quality areas recorded their lowest ozone values ever in 2014. The Houston and Dallas/Fort Worth areas have seen ozone levels reduced 29 and 21%, respectively, during the last 15 years, while the population has increased 34 and 29%. We will continue to expend resources to achieve the 2008 75 ppb ozone standard, which has yet to be fully implemented by the United States Environmental Protection Agency (USEPA). However, as the concentration of ambient ozone decreases, it becomes exponentially more difficult, and expensive, to attain further reductions. USEPA is poised to lower the standard further. While cost cannot be considered in setting the standard, the high cost of further lowering the standard necessitates that this be a sound policy decision and will result in measurable health benefits.

USEPA bases their proposal to lower the ozone standard on three key endpoints - premature mortality, respiratory morbidity (asthma exacerbation, emergency department [ED] visits, hospital admissions [HA]), and lung function (primarily FEV_1 [Forced Expiratory Volume in 1 second, a measure of lung function] decrements). We agree that respiratory effects can occur at the high ozone concentrations that were measured in the 1980's and '90's. The pertinent question is whether lowering the ozone standard from 75 ppb to 70 or 65 ppb will result in a measurable reduction in these effects. In this short review, we consider some important concerns with USEPA's conclusions about the health effects of ambient ozone concentrations. We conclude that USEPA has not demonstrated that public health will measurably improve by decreasing the level of the ozone standard.

Ecological epidemiology studies are not adequate for setting the standard.

USEPA relies heavily on ecological epidemiology studies for their assessment of premature mortality and respiratory morbidity. These studies have been very inconsistent in their findings, and flaws, biases and unusual characteristics of the data have made them difficult to interpret. One unusual and as-yet unexplained characteristic of the epidemiological associations between short-term ozone exposure and mortality is regional heterogeneity. This heterogeneity means that different cities have different associations between short-term exposure to ozone and mortality, and very few of those associations are positive[1-4]. For example, Smith and colleagues[1] found only 7 of the 98 cities investigated showed a statistically significant positive association between 8-hour ozone concentrations and mortality (this is very close to the 5% that would be expected purely by chance). Additionally, there was no association between the estimated effect of ozone on mortality for a city and the concentration of ozone in that city (Figure 1). USEPA[5] estimates short-term mortality impacts based on Zanobetti and Schwartz[4] and the Smith study[1]. However, the Concentration Response Functions (CRFs) vary from negative to positive for the same city, depending on study selection, ozone averaging time, model specifications, and ozone season. In fact, most of these estimates are indistinguishable from zero. USEPA uses a pooled nationwide estimate for their risk calculations, but the substantial heterogeneity between cities that ranges from positive to null or even negative (i.e. higher ozone concentrations correlated with reduced mortality) makes this nationwide estimate misleading and overestimates ozone risk.

The relationship between long-term ozone exposure and mortality has been investigated in at least 12 epidemiology studies[6-17]. When considering other potential causes of mortality, such as other air pollutants, only one of those studies[15] showed a statistically significant (but very small) effect of ozone on respiratory mortality. Interestingly, the effect only occurred at temperatures above 82°F. It is known that very warm or very cold temperatures are associated with increased mortality[18]. Paradoxically, the increased mortality was not observed in US regions with the highest ozone concentrations (southern California) nor in areas with the highest number of respiratory deaths (the northeastern US and the industrial Midwest). Therefore long-term mortality studies also demonstrate unexplained regional heterogeneity and mostly don't show associations between ozone and long-term mortality.

Ecological epidemiology studies suffer from severe exposure measurement error, because they assume that people are continuously exposed (24 hours a day, 7 days a week) to the pollutant concentrations measured at the ambient monitors. In the case of ozone this error is even more egregious, because of the nature of ozone as a pollutant. Ozone is primarily an outdoor pollutant, with ventilation and indoor structures scavenging it and removing it from indoor air. The average American adult, senior citizen and child will spend only 5.3%, 5.8% and 7.9% of their time outdoors, respectively[19], and so they will often not be exposed to ozone. Studies[20-21] that have investigated ozone personal exposure and compared it to ambient concentrations have found that personal exposure is much lower than ambient exposure (about 10% of the measured ambient level), and that there may not even be a correlation between personal and ambient concentrations[22-23]. Even outdoor workers (who

USEPA considers to be an at-risk population) experienced personal ozone concentrations that were only 60% of ambient concentrations[24]. Because of this personal exposure issue, the use of ambient ozone concentrations as a proxy for ozone exposure concentrations grossly overestimates their exposure, and therefore risk. This is particularly true of the short-term mortality data, where the subjects of the study (who are mostly elderly) are within days of death when the ambient concentrations are measured, and so are even less likely to be outdoors. Altogether, this means that it is highly unlikely that the measured associations between ozone and respiratory mortality/morbidity are plausible, because the ozone exposures of the people in the population are so low. Were *all* of the hundreds of thousands of people in the epidemiology studies outside for 8 hours the day immediately before their deaths? In fact, this concern was raised by the Clean Air Scientific Advisory Committee (CASAC) ozone review panel, USEPA's scientific advisors, in a June 5, 2006 letter[25] to USEPA: "The Ozone Staff Paper should consider the problem of exposure measurement error in ozone mortality time-series studies. It is known that personal exposure to ozone is not reflected adequately, and sometimes not at all, by ozone concentrations measured at central monitoring sites....Therefore, it seems unlikely that the observed associations between short-term ozone concentrations and daily mortality are due solely to ozone itself." This difference between ambient ozone concentrations and personal exposures is critical for interpreting both epidemiological studies as well as clinical exposure studies.

Lung function decrements are not likely to be adverse at levels of ozone below the current standard.

The TCEQ agrees with the USEPA that the ozone clinical data are best for setting the ozone standard. The American Thoracic Society (ATS) defines adversity as a significant decrease in FEV_1 with a significant increase in symptoms[26]. The ATS notes that FEV_1 decrements can vary by as much as 5% in healthy adults within a single day and by 15% or more from year to year. USEPA defines a 10% FEV_1 decrement in a sensitive population as an appropriate adverse effect to protect against because it is mild and reversible. USEPA asserts that two clinical studies, by Kim and colleagues[27] and Schelegle and colleagues[28], justify lowering the current 75 ppb standard. The Kim study reported statistically significant FEV_1 decrements (1.71%) in healthy young adults after 6.6 hours of 60 ppb ozone exposure while exercising heavily for 50 minutes out of every hour. However, these decrements are within normal variation and are not adverse by either the ATS criteria (because they were not statistically associated with symptoms), or by USEPA's criteria (they were less than 10%). The Schelegle study reported statistically significant FEV_1 decrements (5.34%, 7.23%, 11.42%, respectively) associated with symptoms in healthy young adults after 6.6 hours exposure to 72, 81, and 88 ppb ozone, but not 63 ppb ozone, while exercising heavily for 50 minutes out of every hour. For 72, 81 and 88 ppb ozone, this exposure meets the ATS criteria for adversity, but at 72 and 81 ppb, it does not meet USEPA's criteria of adversity until 88 ppb, which is above the current standard.

To claim that the lung effects at 60 and 72 ppb from the Kim study and the Schelegle study are adverse, even though the group mean FEV_1 decrements were not adverse, USEPA notes that at 60 ppb, 3 of 59 study subjects had FEV_1 decrements greater than 10%, and at 72 ppb 5 of 31 individual participants had FEV_1 decrements greater than 10%. Therefore, USEPA is essentially basing their assertion of adverse effects occurring at concentrations lower than the current standard on these 8 individual measurements. On the other hand, 5 of 31 individual participants had *increases* in FEV_1 after 72 ppb exposure. The remaining participants showed little, if any, change in FEV_1, altogether confirming the known large inter-individual variability in lung function responses. Lung function returned to baseline for all of the participants within 1-4 hours after cessation of exposure[28]. As noted by Folinsbee and colleagues[29] and McDonnell and colleagues[30], the exposure regimens used in the Kim and Schelegle studies simulate work performed during a day of heavy manual labor in outdoor workers. This is an unrealistic exposure scenario for sensitive subpopulations such as asthmatic children and elderly chronic obstructive pulmonary disease patients. In addition, these lung function decrements would be transient, reversible, would not interfere with normal activity and would not result in permanent injury or respiratory dysfunction[31]. Further, USEPA evaluated these effects based on exposure concentration, not ***dose*** (a function of exposure concentration, time, and ventilation rate). The healthy young study participants exercised vigorously for the majority of their 6.6 hour exposure, dramatically increasing their dose (and therefore response) as compared to a resting or moderate exercise ventilation rate for the same exposure concentration. Given these facts, the USEPA has not demonstrated that lowering the ozone standard from 75 ppb to 70-65 ppb will result in a decrease in **adverse** lung function effects in the population.

The evidence for ozone exacerbation of asthma is insufficient.

USEPA investigated the epidemiology studies that show effects of ambient ozone concentrations on asthma health outcomes. Keeping in mind that these studies suffer from the same exposure measurement errors as the mortality studies, USEPA showed that 21 of the 33 reported associations between ozone and asthma symptoms were not statistically significant, and those that were significant were not consistent with one another[19]. This result is quantified in the regulatory impact analysis[32], where USEPA shows that there is no statistically significant decrease in asthma exacerbations with a decreasing level of the ozone standard. USEPA also states that HA and ED visits are robust to co-pollutant confounders, but does not mention investigation of confounding by pollen, which is a known, strong inducer of asthma[33-34]. Also, confounding by race, ethnicity and household poverty are important considerations, as was shown in a recent study demonstrating that asthma incidence and morbidity is not more associated with urban (more polluted) areas, but rather with ethnicity and poverty[35]. Therefore, USEPA should not have drawn the conclusion that ozone enhances asthma morbidity at ambient concentrations based on this data.

In conclusion, the TCEQ thinks the thoughtful integration of the scientific data does not support the assumption that lowering the ozone standard from 75 ppb to 70–65 ppb will result in measurable health benefits. The ecological epidemiology studies are critically flawed due to severe exposure misclassification because personal exposure to ozone is ~10% of ambient levels, dramatically reducing the ozone dose people actually receive. The clinical studies do not indicate anything beyond mild, reversible effects below 75 ppb. It is biologically implausible that 8-hour ambient ozone concentrations below 75 ppb would cause mortality when they do not cause mild effects.

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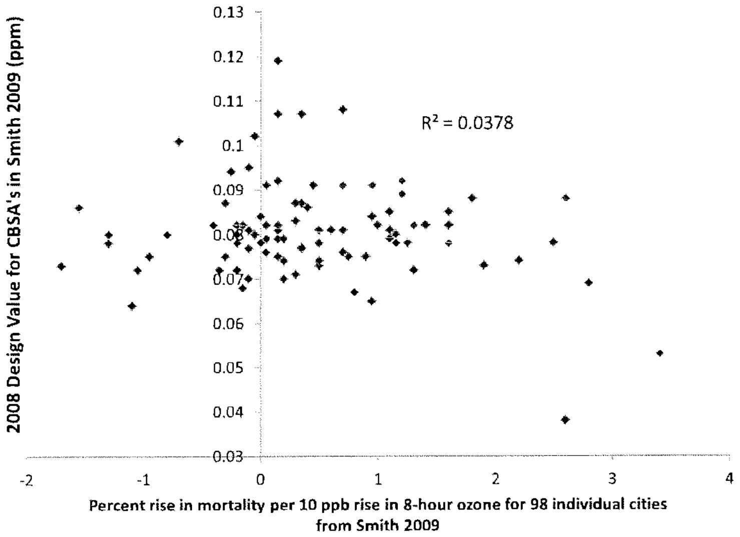

Figure 1. Association between 2008 ozone design values and 8 hour effect estimates of cities from Smith 2009. Approximate mortality effect estimates (in percent rise per 10 ppb increase in 8-hour ozone) from different cities in Smith et al. (2009) are plotted against the 2008 ozone design values (the 4th highest ambient ozone concentration, averaged over the years 2006-2008) for the matched core-based statistical area (CBSA). Blue points represent cities where mortality was not statistically associated with ambient ozone concentration and red points represent cities where mortality was statistically associated with ambient ozone concentration. The correlation coefficient for the relationship between the mortality effect estimates and the ozone design values (R^2) is given. If ozone and mortality were associated, one would expect an increase in mortality as ozone concentrations (design values) increase.

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U.S. NEWS

Los Angeles Sees Health Benefits as Its Smog Haze Clears

Twenty-year USC study shows "significant improvements" in lung function in children

By **ERICA E. PHILLIPS**
March 4, 2015 5:00 p.m. ET

LOS ANGELES—This region of the country, famous for its balmy weather and glamorous lifestyles, is perhaps equally infamous for its congested freeways and signature haze of polluted air.

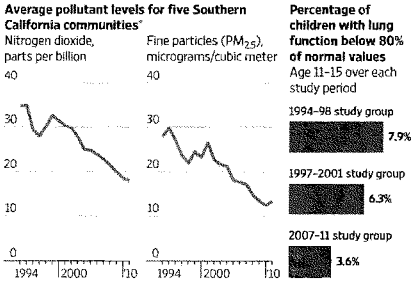
But researchers at the University of Southern California say that reputation may need amending: pollution in L.A. has declined significantly over the past 20 years, they say, and as a result, residents here are healthier.

In findings from a 20-year study to be published Thursday in the New England Journal of Medicine, W. James Gauderman of USC's Keck School of Medicine and several colleagues show that cleaner air in Southern California has led to "significant improvements" in lung function and lung growth among children here.

"The results of our investigation make it clear that broad-based efforts to improve general air quality are associated with substantial and measurable public health benefits," the paper says.

Breathing Easier

A new research paper reports that improved air quality in Southern California has led to stronger lung development among children.



*Long Beach, Mira Loma, Riverside, San Dimas and Upland
Source: Gauderman et al., USC Children's Health Study, New England Journal of Medicine
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The Children's Health Study has measured lung function and development in three separate groups of children during the years 1994-98, 1997-2001 and 2007-11. The children were tested each year from roughly age 11 to 15, when the greatest growth in lung capacity and function occurs.

Earlier published findings from the ongoing Children's Health Study showed that children living in heavily polluted areas experienced stunted lung development, and children living near busy roadways were more likely to develop asthma. The latest findings, Mr. Gauderman said, are more optimistic.

The paper focuses on children in five California communities with heavy air pollution—Long Beach, Mira Loma, Riverside, San Dimas and Upland. Outdoor monitoring stations, which have been measuring air pollution in those areas since 1994, showed large declines in the levels of fine particulate matter and nitrogen dioxide over the past 20 years. As those levels declined, lung-function development among the child subjects of the study—measured as the amount of air one can exhale after taking a deep breath—improved substantially.

That is important, Mr. Gauderman said, because "reduced lung function in adulthood has been strongly associated with increased risks of respiratory disease, cardiovascular disease and premature death."

In Southern California, the sources of air pollution are many, from the millions of vehicles coursing down freeways, to local industry and the trucks, trains and ships moving in and out of the ports of Los Angeles and Long Beach—all of it aggravated by the geography of the L.A. basin, which traps much of that air.

Emissions standards and other local, state and federal regulations implemented in the past two decades have contributed to a major decline in the monitored levels of harmful particulates and chemicals in the air, and the region has seen dramatic improvements in visibility and air quality since the 1990s.

As the air quality improved, it has presented researchers with an opportunity: rather than test whether pollution has adverse effects on health, which many studies have already shown, Mr. Gauderman's team was able to investigate whether improvements in air quality led to better lung health. Their findings indicate that that is indeed the case.

Said Mr. Gauderman: "It's strange to be reporting positive numbers instead of negative numbers after 20 years."

Write to Erica E. Phillips at erica.phillips@wsj.com

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STATE OF WEST VIRGINIA
OFFICE OF THE GOVERNOR
1900 KANAWHA BOULEVARD, EAST
CHARLESTON, WV 25305
(304) 558-2000

EARL RAY TOMBLIN
GOVERNOR

February 19, 2015

The Honorable Gina McCarthy
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Administrator McCarthy:

I have always believed it is critical for my Administration to work with the U.S. Environmental Protection Agency (EPA) to develop reasonable and achievable goals that balance the environmental protection we all want with the opportunity for economic growth that all West Virginians deserve. I appreciate your continued willingness to meet with me to discuss the unique challenges EPA policies present to West Virginia industry, business and our residents. However, I remain concerned many of these policies continue to threaten the livelihood of families and communities in our state.

On December 1, the West Virginia Department of Environmental Protection (WVDEP) filed comments on the EPA's proposal to regulate greenhouse gas (GHG) emissions from existing power plants and expressed numerous practical, legal and economic concerns, not the least of which is the potential loss of thousands of West Virginia jobs and hundreds of millions of dollars in wages.

The EPA is once again considering a rule – this time a stricter ground-level ozone standard – that could have an even more severe impact on West Virginia and our residents.

West Virginia has always made consistent good faith efforts to work with the EPA on a number of environmental protection efforts. We are always willing to discuss reasonable and achievable goals to improve the quality of our environment and have already allocated significant resources and efforts to ensure we comply with the federal ground-level ozone standard of 75 parts per billion (ppb) established in 2008.

The new proposed standard for ground-level ozone, however, is extremely concerning. With work still being done to implement the 2008 standard, this new standard is impractical and unattainable. Forty-five percent of the necessary controls to achieve this standard are classified in the proposed rule as "unknown." With this in mind, the introduction of a new ozone standard has the potential to cause a tremendous negative impact on our state's economy and would make the economic prospects for working families even more challenging.

Though West Virginia maintains a strong commitment to preserving our environment for generations to enjoy, I am simply unable to endorse a proposal that will cause hardship for already-struggling West Virginia families. I urge you to maintain the current ozone standard of 75ppb.

Our WVDEP will be filing formal comments regarding this rule in advance of the comment period deadline.

I sincerely hope we identify a path to balanced environmental policies, and I look forward to working together to find common-sense solutions regarding this issue.

Sincerely,

Earl Ray Tomblin

Earl Ray Tomblin
Governor